THE

HAND-BOOK OF ARTILLERY,

FOR THE

SERVICE OF THE UNITED STATES

(ARMY AND MILITIA.)

INCLUDING THE MANUAL AND MECHANICAL MANŒUVRES OF HEAVY ARTILLERY.

BY

JOSEPH ROBERTS,

LIEUT. COLONEL 4TH ART., AND BVT. BRIG.-GEN., U. S. A.

TENTH EDITION.

REVISED AND GREATLY ENLARGED.

NEW YORK:

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PREFACE TO TENTH EDITION.

Much of the matter in the following compilation is taken from Burns' Questions and Answers on Artillery, Gibbon's Artillerist's Manual, Benton's Ordnance and Gunnery, Heavy and Light Artillery Tactics, the Ordnance Manual, Kingsbury's Artillery and Infantry, Holley's Ordnance and Armor, and the Artillery School Circulars of 1874.

Fort Monroe, Va., 1875.

Report of a Board of Officers convened at Fort Monroe, Va., by virtue of the following order, viz.:—

SPECIAL ORDERS No. 107.

WAR DEPARTMENT,
ADJUTANT GENERAL'S OFFICE,
Washington, June 1, 1875.

(*Extract.*)

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4. A Board of Officers to consist of—

Colonel *G. W. Getty*, 3d Artillery,

Lieutenant Colonel *W. H. French*, 2d Artillery,

Captain *Richard Lodor*, 4th Artillery,

is appointed to meet at Fort Monroe, Virginia, on the 9th day of June, 1875, or as soon thereafter as practicable, to examine and report upon the Revised Hand-Book of Artillery prepared by Lieutenant Colonel *Joseph Roberts*, 4th Artillery.

The junior member of the Board will act as Recorder

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BY ORDER OF THE SECRETARY OF WAR:

E. D. TOWNSEND,
Adjutant General.

OFFICIAL (Signed),

L. H. PELOUZE,
Assistant Adjutant General.

FORT MONROE, VA.

June 11th, 1875

The Board, after the careful examination and review of the 10th Edition of the Revised Hand-Book of Artillery, presented by Lieut. Col. Joseph Roberts, 4th Artillery, find that it differs from the latest (9th) Edition (published 1865), * * * * * * * * in the insertion of new matter pertaining to Rifle Cannon, Rifle Projectiles, Iron Carriages, with description of the new system of U. S. Artillery, originated subsequent to the previous publication.

The Board is of the opinion that the work as revised, will be for Officers, a convenient and useful reference, and is well adapted to the instruction of non-Commissioned Officers and soldiers.

(Signed), GEO. W. GETTY,
Bvt. Major Gen. U. S. A.
and Col. 3d Artillery.

(Signed), WM. H. FRENCH,
Bvt. Major Gen. U. S. A.
and Lieut. Col. 2d Artillery.

(Signed), R. LODOR,
Bvt. Col. U. S. A.
Capt. 4th Artillery.

WAR DEPARTMENT,

June 22d, 1875.

The within proceedings of the Board of Officers are approved. By Order of the Secretary of War,

(Signed), OSCAR A. MACK,
Lt. Col. 21st Inf.,
Bvt. Col. U. S. A.

Official, (Signed) S. N. BENJAMIN,
Asst. Adj. Gen'l.

GENERAL ORDERS No. 3.

WAR DEPARTMENT,
ADJUTANT GENERAL'S OFFICE,
Washington, January 24, 1876.

The manual for serving and working heavy artillery, compiled principally from the drill circulars of the Artillery School, U. S. Army, and published in Appendix No. 2 of the revised (10th) edition of Lieutenant Colonel Roberts' Hand-book of Artillery, is hereby adopted for the U. S. Army until a regular and more comprehensive system of instruction for siege and sea-coast artillery has been authorized by this Department.

In order to secure uniformity of instruction in the drill and mechanical manœuvres of siege and sea-coast artillery, Appendix No. 2 will be strictly adhered to.

BY ORDER OF THE SECRETARY OF WAR:

E. D. TOWNSEND,
Adjutant General.

OFFICIAL:

THE

HAND-BOOK OF ARTILLERY.

PART I. SECTION I.

ARTILLERY IN GENERAL.

1. *What is understood by the term* ARTILLERY?

Cannon of every description with the implements and materials necessary for their use.

2. *How many kinds of cannon are employed in the land service of the United States?*

Three, viz.: Guns, Howitzers, and Mortars.

3. *How are these distinguished?*

According to their use, as Sea-coast, Siege, and Field Artillery.

4. *What metals are used in their construction?*

Bronze, wrought-iron, cast-iron, and steel, alone or in combination.

5. *What is bronze for cannon?*

An ALLOY consisting of 90 parts of copper and 10 of tin, allowing a variation of one part of tin more or less. It is commonly called *brass*.

6. *What are the qualities of bronze?*

Great tenacity and strength, and not being easily corroded by the action of the atmosphere or the gases evolved from gunpowder. Its defects are, the liability of its tin

to be melted away at the sharp corners by the great heat generated by rapid firing, and its softness and consequent liability to serious injury by the bounding of the projectile in the bore.

7. *What are the qualities of wrought-iron?*

Softness, ductility and great tenacity. On account of its softness the bore of a cannon made of wrought-iron is liable to be enlarged under heavy charges of powder. It is easily corroded by the action of the atmosphere and of the powder, and in consequence of the latter action the vent and small cavities of a wrought-iron gun become rapidly enlarged by use. In consequence of false welds and cracks in large masses of wrought-iron and a spongy and irregular crystalline structure, it has been found impracticable to make reliable *solid* wrought-iron cannon of large calibre. In *built-up* cannon made of wrought-iron alone, the defects mentioned are obviated by first forming them in small masses, as rings, tubes, etc., of good quality, and then uniting them separately.

8. *What is cast-iron?*

A compound of pure iron and carbon.

9. *What are its qualities?*

Its qualities are hardness, tenacity and cheapness. It has, however, very little elasticity and ductility compared to wrought-iron and bronze. Its structure, even in large masses, is generally uniform and homogeneous. It is used for making smooth bore cannon of large calibre, but it is not generally considered reliable for heavy rifled cannon.

NOTE.—Steel is also a compound of iron and carbon in which the proportion of the latter seldom exceeds 1.7 per cent.

10. *Why was bronze formerly preferred for field pieces?*

This metal having greater tenacity and strength than

cast-iron, the only other metal then employed in making cannon, the pieces could be made lighter.

11. *In what respect does cast-iron merit a preference?*

It is less expensive than bronze, and is more capable of sustaining long-continued firing with larger charges; such cannon are, therefore, better calculated for the constant heavy firing of sieges.

NOTE.—In the sieges in Spain, bronze guns could never support a heavier fire than 120 rounds in twenty-four hours, and were never used to batter at a distance exceeding 300 yards; whereas, with iron guns, three times that number of rounds were fired with effect, from three times the distance, for several consecutive days, without any other injury than the enlargement of their vents. The comparative power of conducting heat in iron and copper being respectively as 3.743 to 8.932, taking gold at 10.000, it is evident that in practising with iron and bronze pieces of the same calibre, it would soon become necessary to reduce the charges in bronze pieces, and also to increase the time between the discharges, to prevent their softening and drooping; while with iron, full charges and rapid firing may be kept up.

12. *What additional objection has been urged to bronze for cannon?*

The difficulty of forming a perfect alloy, in consequence of the difference of fusibility of tin and copper.

13. *What iron pieces are adopted for the land service?*

3, 3½, 4½, 10, and 12-in. rifled guns; 13, 15, and 20-in. smooth bore (Rodman) guns; 8-in. howitzer; 8 and 10-in. siege mortars; 13 and 15-in. sea-coast mortars.

NOTE.—The Gatling gun, recently adopted, is made of *steel*, some of the smaller parts being of brass.

The 8 and 10-in. smooth bore guns, the 24-pdr. Flank Defence howitzer, and the 10-in. sea-coast mortar no longer belong to the *system*, and no more are to be cast.

Experiments, which promise to be successful, are now in pro-

gress, with the view of converting the 10-in. smooth bore guns, of which there is a large number on hand, into 8-in. rifles, by fitting to them an internal tube of steel or wrought-iron after the plans of Palliser or Parsons in England. The 13-in. smooth bore, and the 10 and 12-in. rifles may be regarded as experimental guns, not more than two or three of each kind having been cast. No ranges from experimental firing with them have yet been determined. The experiments conducted thus far with them have been mostly with the view of testing different kinds of gunpowder. No 3½-in. rifles nor 15-in. mortars have yet been constructed.

14. *What are the kinds of bronze cannon in use at present?*

12-pdr. field gun; 12-pdr. mountain howitzer; and the 24-pdr. Coehorn mortar.

15. *What is a battery?*

This term is applied to one or more cannon, or to the place where they are served.

16. *What regulate the dimensions of a piece?*

Its calibre and the tenacity and elasticity of the metals employed in its fabrication. Its thickness must be proportioned to the variable action of the powder and projectile along the bore; and the length is determined by experiment. The thickness is greatest at the seat of the charge and least at or near the muzzle. The exterior surface of a gun of the most recent models is free from mouldings and ornaments, and the elements are curved instead of right lines.

17. *Why is a piece made stronger near the breech than towards the muzzle?*

Because the elastic force of the inflamed gunpowder is there greatest, constantly diminishing in intensity as the space increases in which it acts.

18. *What is the length of a piece?*

The distance from the rear of the base-ring to the face of the piece.

19. *What is the extreme length?*

From the rear of the cascable to the face.

20. *What is the* BORE *of a piece?*

It includes the part bored out, viz.: the cylinder, the chamber (if there is one), and the conical or spherical surface connecting them.

In *all* pieces of the *late* models, viz.: those constructed in 1861 and since, the bore is a cylinder, terminating at the bottom in a semi-ellipsoid.

21. *What is understood by the* CALIBRE *of a piece?*

The diameter of the bore.

22. *How do you ascertain the number of calibres in a piece?*

Divide the length of the cylinder, in inches, by the number of inches in the calibre.

23. *The number of calibres being known, how do you find the length of the cylinder?*

Multiply the number of calibres by the calibre in inches.

24. *What is meant by the* SIGHTS *of a piece?*

Artificial marks on the piece for determining the line of fire.

25. *How are the sights determined?*

Usually by means of the gunner's level, when the trunnions are perfectly horizontal.

26. *What is the* LINE OF METAL *or the natural line of sight?*

A line drawn from the highest point of the base-ring or base line to the highest point of the swell of the muzzle, or to the top of the sight, if there be one.*

* The line of sight nearest to the axis of the piece is the *natural line of sight*; the others are *artificial lines of sight*.

27. *What is the* AXIS *of a piece?*

The central line of the bore.

28. *What is the* NATURAL ANGLE OF SIGHT?

The angle which the natural line of sight makes with the axis of the piece.

29. *What is the* DISPART *of a piece?*

It is the difference of the semi-diameters of the base-ring and the swell of the muzzle, or the muzzle-band. It is, therefore, the tangent of the natural angle of sight to a radius equal to the distance from rear of the base-ring, or base-line, to the highest point of the swell of muzzle, or to the top of the front sight if there be one, measured parallel to the axis.

30. *Give the nomenclature* of a piece.*

The CASCABLE is the projection in rear of the breech, and is composed of the *knob*, the *neck*, and the *fillet*.

The BASE OF THE BREECH is the rear surface of the breech.

The BASE-LINE is a line traced around the gun in rear of the vent.

The BASE-RING is a projecting band of metal adjoining the base of the breech, and connected with the body of the gun by a concave moulding.

The BREECH is the mass of solid metal behind the bottom of the bore, extending to the cascable.

The REINFORCE is the thickest part of the body of the gun, in front of the base-ring or base-line: if there be more than one *reinforce*, that which is next the base-ring

* Most of this nomenclature applies only to cannon of the old pattern, the later models having no mouldings or ornaments, and the elements being curved instead of right lines.

or base-line is called the *first reinforce ;* the other the ***second reinforce.***

The **REINFORCE BAND** is at the junction of the first and second reinforces.

The **CHASE** is the conical part of the gun in front of the reinforce.

The **ASTRAGAL AND FILLETS** are the mouldings at the front end of the chase.

The **CHASE-RING** is a band at the front end of the chase.

The **NECK** is the smallest part of the piece in front of the chase.

The **SWELL OF THE MUZZLE** is the largest part of the gun in front of the neck.

The **FACE** of the piece is the terminating plane perpendicular to the axis of the bore.

The **TRUNNIONS** are two cylinders at or near the centre of gravity of a gun, by which it is supported on its carriage. The axes are in a line perpendicular to the axis of the bore, and, in our guns, in the same plane with that axis.

The **RIMBASES** are short cylinders uniting the trunnions with the body of the gun. The ends of the rimbases, or the *shoulders* of the trunnions, are planes perpendicular to the axis of the trunnions.

NOTE.—Rimbases are for the purpose of strengthening the trunnions at their junction with the piece, and by forming shoulders, to prevent the piece from moving *sideways* in the trunnion beds.

The **BORE** of the piece includes all the part bored out, viz.: the cylinder, the chamber (if there is one), and the conical or spherical surface connecting them.

The **CHAMBER** in howitzers, and mortars of the old model, was the smallest part of the bore, and contained the charge of powder. In the howitzers the chamber was

cylindrical; and was united with the large cylinder of the bore by a conical surface; the angles of intersection of this conical surface with the cylinders of the bore and chamber, were rounded (in profile) by arcs of circles. In the 8-in. siege howitzer, the chamber was united with the cylinder of the bore by a spherical surface, in order that the shell might, when necessary, be inserted without a sabot.

The *chamber* is omitted in all cannon of the late models, the cylinder of the bore terminating at the bottom in a semi-ellipsoid.

The MUZZLE, or mouth of the bore, is chamfered to a depth of 0.15 inch to 0.5 inch (varying with the size of the bore), in order to prevent abrasion, and to facilitate loading.

31. *What is the vent?*

The aperture through which fire is communicated to the charge.

32. *What is to be observed in reference to the diameter of the vent?*

It should be as small as the use of the priming wire and tube will allow.

33. *Why?*

As the velocity of the gases arising from the combustion of the powder is extremely great, a large amount escapes through the vent, which contributes nothing to the velocity of the projectile. It therefore follows, that the effect produced by a given charge will diminish as the diameter of the vent increases. Besides, on account of the increase of power in the current that escapes from them, large vents are more rapidly injured than small ones.

34. *What is the diameter of the vent?*

0.2 of an inch in all cannon.

35. *What is the position of the axis of the vent?*

In the old models it was in a plane passing through the axis of the bore, perpendicular to the axis of the trunnions. In guns, and in howitzers having cylindrical chambers, the vent was placed at an angle of 80° with the axis of the bore, and it entered the bore at a distance from the bottom equal to one-fourth the diameter of the bore. The vents, of which there are two in mortars of late models and in the new Rodman guns, are in planes parallel to the plane passing through the axis of the bore, and perpendicular to that of the trunnions, and at a distance from it equal to one-half the radius of the bore. The vents are perpendicular to the axis of the bore; the one on the right of the axis is not bored entirely through to the bore by one inch. The vent of field and siege pieces is at right angles to the axis and in the plane passing through it perpendicular to the axis of the trunnions.

NOTE.—The oblique position of the vent insured the pricking of the cartridge when it was not rammed completely home; the perpendicular position prevents the friction tube from being pulled out in firing.

36. *What are the* QUARTER-SIGHTS *of a piece?*

Divisions marked on the upper quarters of the base-ring, commencing where it would be intersected by a plane parallel to the axis of the piece, and tangent to the upper surface of the trunnions.

NOTE.—Not used in our service.

37. *To what use are the quarter-sights applied?*

For giving elevations up to three degrees; but especially for pointing a piece at a less elevation than the natural angle of sight.

38. *What is a* TANGENT SCALE?

A brass plate, the lower edge of which is cut to fit the

base-ring or base-line of the piece and the upper edge cut into notches for each ¼ degree elevation. It is used in pointing, by placing the lower edge on the base-ring or base-line with the radius of the notch corresponding with the highest point of the base-ring or line, and sighting over the centre of the notch and the highest point of the muzzle or top of the muzzle sight.

39. *What is a* BREECH SIGHT?

An instrument having a graduated scale of tangents by means of which any elevation may be given to a piece. Correctly speaking, the breech sight gives the angle made by the line of aim or sight with the axis of the piece. The base of the *breech sight* is a plate of brass curved to fit the base-ring or line, the scale and slides are similar to those of the pendulum hausse except that a hole is made in the plate, instead of a notch, to sight through. Breech sights are graduated for *no disparts*, a *front sight* equal in height to the dispart being screwed into the top of the muzzle; in the Rodman guns, into the seat provided for the purpose between the trunnions.

We have also breech sights, cylindrical in shape, which fit in sockets placed in the centre of or on the right side of the breech, the front sight being either between the trunnions or on the *right* trunnion.

40. *How are the divisions of the scale found?*

By taking the length of the piece, from the rear of the base-ring to the swell of the muzzle, measured on a line parallel to the axis, and multiplying it by the natural tangent of as many degrees as may be required; and then deduct the dispart. Thus, for 5° elevation, and the gun supposed to be 5 feet, or 60 inches long, multiply .08748, which is the natural tangent of 5°, by 60; the product gives 5.2488 inches; supposing the dispart to be 1 inch,

the graduating of the tangent scale will be 4.2488 inches.

41. *With what pieces are breech-s ghts used?*

Guns and howitzers.

42. *What is a* PENDULUM HAUSSE?

It is a scale of sheet brass, the graduations of which are the sines of each quarter of a degree to a radius equal to the distance between the muzzle-sight of the piece, and the axis of vibration of the hausse, which is one inch in rear of the base-ring. At the lower end of the scale is a brass bulb filled with lead. The *s'ider* which marks the divisions on the scale is of thin brass, and is clamped at any desired division on the scale by means of a screw. The scale passes through a slit in a piece of steel, with which it is connected by a screw, forming a pivot on which the scale can vibrate laterally. This piece of steel, terminates in pivots, by means of which the pendulum is supported on the *seat* attached to the gun and is at liberty to vibrate in the direction of the axis of the piece. The *seat* is of metal, and is fastened to the base of the breech by screws, so t at the centres of the steel pivots of vibration shall be at a distance from the axis of the piece equal to the radius of the base-ring.

A MUZZLE-SIGHT of iron is screwed into the swell of the muzzle of guns, or into the middle of the muzzle-ring of howitzers. The height of this sight is equal to the dispart of the piece, so that a line joining its top and the pivot of the scale, which is the zero point, is parallel to the axis of the piece.

Consequently, the vertical plane of sight passing through the centre line of the scale and the top of the muzzle-sight will be also parallel to the axis in any position of the piece; the hausse will therefore always indicate correctly the angle which the line of sight makes with

the axis. Each piece must have its own scale, seat, and muzzle-sight. This instrument is used with our field artillery which is served on rough and uneven ground.

43. *What is a* GUNNER'S LEVEL, *or gunner's perpendicular?*

An instrument made of sheet-brass; the lower part is cut in the form of a crescent, the points of which are made of steel; a small spirit-level is fastened to one side of the plate, parallel to the line joining the points of the crescent, and a slider is fastened to the same side of the plate, perpendicular to the axis of the level.

44. *What is it used for?*

To mark the points of sight on pieces.

By means of the bubble the feet or points of the crescent are placed on a horizontal line on the base-ring or base-line, the slider pushed down until the point rests on the base-ring or line, and its position marked with chalk.

45. *What is a* PLUMMET?

A simple *line* and *bob* for pointing mortars.

46. *What is a* GUNNER'S QUADRANT?

It is a graduated quarter of a circle of sheet-brass of 6 inches radius, attached to a brass rule 22 inches long. It has an *arm* carrying a spirit level at its middle, and a vernier at its movable end. To get a required elevation, the vernier is fixed at the indicated degree, the brass rule is then inserted in the bore parallel to the axis of the piece; the gun is then elevated or depressed until the level is horizontal.

There is also a graduated quadrant of *wood*, of 6 inches radius, attached to a rule 23.5 inches long. It has a *plumb-line* and *b b*, which are carried, when not in use, in a hole in the end of the rule, covered by a brass plate.

47. *What is an* ELEVATING ARC, *and its use?*

It is an arc attached to the base of the breech parallel to the ratchets and graduated into degrees and parts of a degree. A pointer attached to the *fulcrum* * points to the zero of the scale when the axis of the piece is horizontal. Elevations and depressions are indicated by the scale.

Besides the graduations on the arc, the ranges (in yards) and the charges for shot and shell are given.

48. *What is the use of the cascable?*

To facilitate the handling of the piece in mounting and dismounting it, and moving it when off its carriage.

49. *Of what use are the trunnions of a piece?*

By means of them the piece is attached to its carriage; and by being placed at or near the centre of gravity, it is easily elevated or depressed.

50. *What were the dolphins of a piece?*

Two handles placed upon the piece with their centres over the centre of gravity, by which it was mounted or dismounted.

51. *Are they now in use in our service?*

No.

52. *What is understood by the preponderance of a piece?*

It is the excess of weight of the part in rear of the trunnions over that in front; it is measured by the lifting force in pounds, which must be applied at the rear of the *base-ring*, at the base-line, or at the bottom of the ratchet, to balance the piece when suspended freely on the axis of the trunnions.

53. *Why was preponderance given?*

It was supposed to prevent the sudden dipping of the

* *It* is so named in the Ord. Manual, but in the Heavy Artillery tactics and in Appendix No. 2 of this Hand-Book it is called the "ratchet-post."

muzzle, in firing, and violent concussion on the carriage at the breech.

NOTE.—Most of the heavy pieces of the late models have no *preponderance*, the axis of the trunnions intersecting the axis of the piece, at the centre of gravity. General Rodman has shown that cannon so constructed do not sensibly change their position before the projectile leaves the bore, and that accuracy of fire is not affected. Guns to be cast hereafter, are to have no preponderance.

54. *What is bushing a piece of artillery?*

Inserting a piece of metal about an inch in diameter (near the bottom of the bore), through the centre of which the vent has been previously drilled. It is screwed in.

55. *What kind of metal is used for bushing bronze pieces?*

Pure copper always, which is not so liable to run from heat as gun metal.

56. *What is the object of bushing a piece?*

To prevent deterioration of the vent, or provide a new one when this has already occurred.

57. *Is all new artillery bushed?*

No, only rifled and bronze pieces.

58. *How are vents replaced?*

The vent-piece in bronze and rifled pieces is taken out, and a new one screwed in. In *other pieces* the vent is filled up by molten zinc, clay being placed on the head of a rammer, and pressed against the upper surface of the bore, so as to close the vent on the interior, and then the one on the right of the axis is bored entirely through, or a new one is bored two or three inches from the others.

59. *How is artillery rendered unserviceable?*

I. Drive into the vent a jagged and hardened steel spike with a soft point, or a nail without a head; break it off flush with the outer surface and clinch the point inside by means of a rammer.

II. Wedge a shot in the bottom of the bore by wrapping it with felt, or by means of iron wedges, using the rammer or a bar of iron to drive them in.

III. Cause shells to burst in the bore of bronze guns.

IV. Fire broken shot from them with large charges.

V. Fill the piece with sand over the charge, to burst it.

VI. Fire a piece against another, muzzle to muzzle, or the muzzle of one to the chase of the other.

VII. Light a fire under the chase of a bronze gun, and strike on it with a sledge, to bend it.

VIII. Break off the trunnions of iron guns ; or burst them by firing them at a high elevation, with heavy charges and full of shot.

60. *State how to unspike a piece.*

If the spike is not screwed in or clinched, and the bore is not impeded, put in a charge of powder $\frac{1}{3}$ of the weight of the shot, and ram junk wads over it; laying on the bottom of the bore a slip of wood, with a groove on the under side containing a strand of quick-match, by which fire is communicated to the charge. In a brass gun, take out some of the metal at the upper orifice of the vent, and pour sulphuric acid into the groove, and let it stand some hours before firing. If this method, several times repeated, is not successful, unscrew the vent piece if it be a brass gun ; and if an iron one, drill out the spike, or drill a new vent.

61. *Explain how to drive out a shot wedged in the bore*

Unscrew the vent-piece, if there be one, and drive in wedges so as to start the shot forward, then ram it back again in order to seize the wedge with a hook ; or pour in powder, and fire it after replacing the vent-piece. In the

last resort, bore a hole in the bottom of the breech, drive out the shot, and stop the hole with a screw.

NOTE.—*When a shot is jammed in a gun and cannot be rammed home to the cartridge*, destroy the charge by pouring water down the vent and muzzle until the ingredients are dissolved, and cleared out of the bore; then introduce a small quantity of powder through the vent, and blow out the shot.

62. *Explain how to use a piece which has been spiked.*

Insert one end of a piece of quick-match into the cartridge, the other being allowed to project from the muzzle. Apply the fire to the quick-match and get out of the way. When quick-match of sufficient length is not at hand, insert one end in the cartridge, the other projecting in front of the shot, and throw two or three pinches of powder into the bore, after they are rammed home. Place another piece of match in the muzzle, one end projecting out. The fire is applied without danger.

63. *What is scaling a piece of artillery?*

Flashing off a small quantity of powder to clean out the bore; about $\frac{1}{12}$ of the shot's weight. The practice is discontinued.

64. *How are cannon of the old models in our service marked?*

As follows, viz.: The *number of the gun* and *the initials of the inspector's name* on the face of the muzzle,—the numbers in a separate series for each kind and calibre at each foundry; the initial letters of the *name of the founder*, and of the foundry, on the end of the right trunnion; the *year of fabrication* on the end of the left trunnion; *the foundry number* on the end of the right rimbase, above the trunnion; *the weight of the piece in pounds* on the base of the breech; the letters U. S. on the upper surface of the piece, near the end of the reinforce.

65. *How are the new pieces marked?*

As follows, viz.: the *number of the gun*, the *initials of the inspector's name*, and *that of the foundry*, the *year of fabrication*, and *the weight of the piece in pounds* on the face of the piece, in a circle concentric with the bore, in letters and figures at least one inch long; the numbers, in a separate series for each kind and calibre at each foundry; the *foundry number*, in small figures, on the end of the right rimbase, above the trunnion; the letters U. S., in large characters, on the upper surface of the piece, in rear, but near the trunnions.

66. *What marks are used to designate condemned pieces?*

Pieces rejected on inspection are marked X C on the face of the muzzle; if condemned for erroneous dimensions which cannot be remedied, add X D; if by powder proof, X P; if by water proof, X W.

67. *What are the kinds of proof which artillery must undergo, before being received into the service?*

1st. They are gauged as to their several dimensions, internal and external; as to justness and position of the bore, the chamber, vent, trunnions, &c.

2d. They are fired with a regulated charge of powder and shot, being afterwards searched to discover irregularities or holes produced by the firing.

3d. By means of engines, an endeavor is made to force water through them.

4th. They are examined internally, by means of light reflected from a mirror.

NOTE.—The selection of the metal is left now to the private founders, and it is required that one gun out of a certain number shall be selected and proved in the ordinary way, and afterwards fired continuously 1000 service rounds; if the result is satisfactory,

all other guns must be made precisely like it. Every gun, however, must undergo the usual proof before being received into the service.

68. *Are brass cannon liable to external injury, caused by service?*

They are little subject to such injury, except from the bending of the trunnions sometimes, after long service, or heavy charges.

NOTE.—Experiments at Fort Monroe show that brass guns, when *rifled*, and fired with large charges and heavy shot, expand so much that the projectile does not take the grooves.

69. *What are the causes of internal injury?*

Internal injuries are caused by the action of the elastic fluids developed in the combustion of the powder, or by the action of the shot in passing out of the bore. These effects generally increase with the calibre of the piece.

70. *Name the principal injury of the first kind.*

The cutting away of the metal of the upper surface of the bore over the seat of the shot.

71. *Name those of the second kind.*

The *lodgment of the shot*,—a compression of the metal on the lower side of the bore, at the seat of the shot, which is caused by the pressure of the gas in escaping over the top of the shot. There is a corresponding *burr* in front of the lodgment; and the motion thereby given to the shot causes it to strike alternately on the top and bottom of the bore, producing other *enlargements*, generally *three* in number: the first, on the upper side a little in advance of the trunnions; the second, on the lower side about the astragal; the third, in the upper part of the muzzle; it is chiefly from this cause that brass guns become unservice-

able. *Scratches*, caused by the fragments of a broken shot, or the roughness of an imperfect one.

72. *When is a piece said to be honeycombed?*

When the surface of the bore is full of small holes and cavities.

73. *To what is this due?*

To the melting and volatilization of a portion of the tin in the alloy; tin being much more fusible than copper.

74. *How may the durability of bronze guns be increased?*

By careful use, and by the precautions of increasing the length of the cartridge, or that of the *sabot*, or using *a wad over the cartridge*, in order to change the place of the shot; by *wrapping the shot in woollen or other cloth*, or in *paper*, so as to diminish the windage and the bounding of the shot in the bore. In *field guns*, the paper cap which is taken off the cartridge should always be put over the shot.

75. *To what injuries are iron cannon subject?*

To the above defects in a less degree than brass, except the corrosion of the metal, by which the vent is rendered unserviceable from enlargement. The principal cause of injury to iron cannon is the rusting of the metal, producing a roughness and enlargement of the bore, and an increase of any cavities or honeycombs which may exist in the metal.

76. *How may you judge of the service of an iron smooth bore gun?*

Generally by the appearance of the vent. After about 500 rounds the vent becomes enlarged to 0.3 inch, and should not be used any longer. In rifled guns the wear of the vent is about twice as great as in smooth bore guns.

77. *What rules are laid down for the preservation of artillery?*

Cannon should be placed together, according to kind and calibre, on skids of stone, iron, or wood, laid on hard ground well rammed and covered with a layer of cinders or of some other material to prevent vegetation. In case of *guns and long howitzers*, the pieces should rest on the skids in front of the base ring and in rear of the astragal, the axis inclined at an angle of 4° or 5° with the horizon, the muzzle lowest, the trunnions touching each other; or the trunnion of one piece may rest on the adjoining piece, so that the axis of the trunnions may be inclined about 45° to the horizon; the muzzle closed with a tompion or plug of dry wood, well saturated with oil or grease; the vent down, stopped with a greased wooden plug, or with putty or tallow. The pieces may be piled in two tiers, with skids placed between them exactly over those which rest on the ground; the muzzles of both tiers in the same direction and their axis preserving the same inclination. In case of *short howitzers and mortars*, the pieces should stand on their muzzles, resting on thick planks, the trunnions touching, the vents stopped.

78. *What additional precautions should be observed in case of iron pieces?*

They should be covered on the exterior with a lacker impervious to water; the bore and the vent should be greased with a mixture of *oil* and *tallow*, or of *tallow* and *beeswax* melted together and boiled to expel the water. The lacker should be renewed as often as necessary, and the grease at least once a year. The lacker and grease should be applied in hot weather. The cannon should be frequently inspected, to see that moisture does not collect in the bore.

79. *What is* DIRECT FIRE?

Direct fire is where the projectile strikes the mark without touching the intermediate ground, *the piece being aimed directly at the object.*

80. *What is* PLUNGING FIRE?

Plunging fire is where the object is situated below the piece. This fire is very effective against the decks of vessels.

81. *What is the* VELOCITY *of a projectile at any point of its flight?*

It is the rate of motion of the projectile, and is measured by the space in *feet* which it would pass over in *one second* of time supposed to move uniformly with this velocity during the second.

82. *What is* INITIAL *velocity of a projectile?*

The velocity at the *muzzle* of the piece.

83. *What is* REMAINING *velocity?*

The velocity at any point of the flight.

84. *What is* TERMINAL *velocity?*

The velocity with which it strikes the object.

85. *What is* FINAL *velocity of descent in air?*

The uniform velocity with which a projectile moves when the resistance of the air becomes equal to the accelerating force of gravity.

PART I. SECTION II.

ON GUNS.

1. *What are* GUNS?

Long cannon for firing solid as well as hollow projectiles.

2. *How are guns denominated?*

Sometimes by the weight of their respective shot; but usually by the diameter of the bore in inches.

3. *What are the principal parts of a gun?*

The cascable, breech, reinforce, chase, muzzle, vent, and bore.

4. *How are guns classified?*

Into smooth bore and rifle cannon.

5. *Name the smooth bore guns adopted for our service.*

12-pdr.; *13-in.; 15-in.; and 20-in.

6.* *Name the rifle guns adopted for our service.*

3-in.; 3½-in.; 4½-in.; 10-in.; 12-in.; and the Gatling gun.

7. *What is a rifle?*

A fire-arm having a number of spiral grooves cut into the surface of its bore for the purpose of giving the projectile a motion of rotation about a line coinciding with the direction of its flight.

8. *What are the advantages of this rotation?*

It increases the range of the projectile by causing it to move through the air in the direction of its least resistance, and corrects the cause of deviation by distributing it uniformly around the line of flight.

9. *What are the leading systems at present for rifle guns?*

1st. The FLANGED system, which embraces all projectiles upon the cylindrical portion of which are projections such as *studs* or *buttons*, *ribs* and *flanges*, which, in loading, are intended to be inserted into corresponding grooves in the bore of the gun. (the Lancaster, Whitworth and Sawyer systems, and the *French* or the *Woolwich* systems.)

* See NOTE to the answer to question 13, page 9.

2d. The COMPRESSING system, where the projectile is larger than the bore and entering at the breech into a chamber larger than the rest of the bore is at the time of discharge squeezed or planed to fit the bore by the *lands* of the rifling, (the Armstrong breech-loading system.)

3d. The EXPANSION system, in which the body of the projectile is generally of cast-iron and the rear a band or cup of some softer metal, as *pewter*, *copper*, or *wrought iron*, which enters the bore of the piece freely in loading, but which is forced by the discharge into the grooves of the gun, (the Parrott, James, Hotchkiss, Stafford, Schenkl, Butler, Arrick and Blakely systems.)

NOTE.—The *expansion system* is used on the most extensive scale in the United States; in England it is experimental, and has not been adopted. On the Continent it is scarcely recognized. The plan of rifling in the United States is lands and grooves of the same or nearly equal width. All the standard army and navy projectiles (except Sawyer's), viz: James', Hotchkiss', Schenkl's, Parrott's and Stafford's are *expanding* projectiles; they may be used in any gun of proper calibre irrespective of the width or depth of the grooves.

10. *What determines the form of the spiral grooves?*

The angle which the tangent line at any point makes with the corresponding element of the bore. If this angle be the same at every point, the groove is said to be *uniform*. If it increases from the breech to the muzzle, the groove is called *increasing*; if the reverse, *decreasing*.

11. *Describe the different modes of cutting the grooves?*

1st. The barrel may have both a motion of translation and rotation, whilst a stationary cutter presses upon it.

2d. The barrel may have only a motion of rotation while the cutting point is given a motion of translation.

3d. The barrel may remain stationary, and the point have both motions.

12. *Which of these is the practical method of rifling a gun?*

The last; a rod armed with a cutter is moved by machinery back and forth in the bore, and at the same time revolved around its axis. If the velocities of translation and rotation be both uniform, the grooves will be *uniform;* if one of the velocities be variable, the grooves will be either *decreasing* or *increasing*, depending on the relative velocities in the two directions.

13. *What is understood by the term* TWIST?

It is employed by gun-makers to express the inclination of a groove at any point, and is measured by the tangent of the angle made by the groove with the axis of the bore.

14 *To what is this tangent equal?*

To the quotient obtained by dividing the circumference of the bore by the length of one revolution of the spiral estimated in the direction of the axis.

15. *Has the most suitable inclination of grooves for a rifle cannon yet been determined?*

No; a wide diversity of twists is employed by different experimenters.

16. *What metal is the 12-pdr. gun made of?*

Bronze.

17. *Describe this gun.*

It is known as the Napoleon gun, and dates from 1856. The bottom of the bore is a plane surface perpendicular to its axis and united with the sides (in profile) by an arc of a circle the radius of which is one-fourth of the diameter of the bore. The interior orifice of the vent is at a distance from the bottom of the bore equal to the same radius. Its exterior is free from mouldings and ornament. It has but one reinforce, and this is cylindrical, the exterior tapering

uniformly from the extremity of the reinforce to the muzzle.

18. *What metal is the 3-in. gun made of?*

Wrought-iron, and it is the only cannon of this metal in our service.

19. *How is it fabricated?*

By wrapping plates of boiler iron around an iron bar, so as to form a cylindrical mass of a given diameter, and placing the whole in a furnace and bringing it to a welding heat, and then passing it between rollers to unite it solidly together. The trunnions are afterwards welded on and the piece bored and turned to the proper size and shape.

20. *What is the form of this gun?*

Its exterior is entirely free from moulding and ornament, and is the same in general appearance as all the guns of the Rodman pattern. The bottom of the bore is a semi-ellipsoid.

NOTE.—The model for the 3½-inch rifle was adopted in 1870. It is to be made of wrought-iron or bronze, and in its general appearance will closely resemble the 3-in. rifle.

21. *Describe the Gatling gun.*

The Gatling gun is a machine gun, the 1-in. composed of six and the ½-in.* of ten rifled barrels of steel, made to revolve around a central axis, parallel to their bores, by means of a hand crank. As each barrel comes opposite to the hopper on the left side of the cylinder, a self-primed metal case cartridge falls into a groove of the cartridge carrier, is pressed into the breech by a plunger, and

* This calibre is to be reduced to .45 inch., in order to use with it the projectile of the breech-loading musket.

held there until exploded by the firing pin. The empty case is withdrawn from the barrel by an extractor attached to the cylinder containing the firing pin. With each revolution of the crank the 1-in. gun fires once, and the ½-in. gun three times.

22. *Of what metal are the other guns made?*

They are all made of cast-iron, and, with the exception of the 4½-in. gun, cooled from the interior after the plan of Gen. Rodman. They are of the Rodman pattern, their exterior being free from moulding and ornament, and their bores cylindrical, terminating at the bottom in a semi-ellipsoid.

23. *Upon what are guns mounted?*

On field, siege, barbette or casemate carriages.

24. *What projectiles are used with guns?*

Solid shot, shells, spherical-case, grape, and canister.

WEIGHTS AND DIMENSIONS OF THE DIFFERENT GUNS.

	12-pdr.	3-in.	3½-in.	4½-in.	10-in. rifle.	12-in.	10-in. sm'th bore.	13-in.	15-in.	20-in.	Gatling. 1-in.	Gatling. 0.5-in.
Weight, lbs.	1227	820	1156	3570	40681	52000	15000	37000	49000	116000	1008	365
Length of bore in diameters..............	13.75	21.5	21.5	26.5	15.85	14.00	12.	12.00	11.00	10.50	33.00	64.00
Extreme length in inches	72.15	72.70	73.84	133.00	180.00	192.00	136.60	177.60	190.00	243.50	60.00	60.00
Maximum diameter, in inches	13.00	9.42	.....	15.60	41.60	48.00	32.00	41.60	48.00	64.00	.....	.....
Minimum diameter, in inches	8.50	6.00	.....	9.00	21.00	25.00	16.20	21.00	25.00	34.3	.....	.....

The Ordnance Board has proposed the following model for the 12-in. rifle. viz.: extreme length, 263 inches; length of bore, 19.33 diameters; maximum diameter, 55 inches; diameter at muzzle, 26 inches; weight, 89014 lbs.; twist, one turn in 70 feet: and the following for the 15-in. smooth bore, viz.: extreme length, 215 inches; length of bore, 12.66 diameters; maximum diameter, 51 inches; diameter at muzzle, 24.7 inches; weight 57440 lbs.

25. *What guns have preponderance, and how much?*

12-pdr. 105 lbs.; 3-in., 40 lbs.; 4½-in., 300 lbs.; Gatling, ½-in. 45 lbs., 1-in. 110 lbs.

26. *How is it in regard to the other guns?*

They are made without preponderance, their elevation and depression being effected by a lever, one end of which works in a ratchet cut in the breech of the piece at right angles to the axis of the trunnions.

27. *Describe the grooves of the rifled guns adopted in our service.*

Number of grooves.	3-in.	7
	3½-in.	7
	4½-in.	9
	10-in.	17
	12-in.	2[illegible]
	Gatling ½-in.	6
	" 1-in.	6
Width of grooves..	3-in.	0.84 in.
	4½-in.	0.97 "
	10-in	1.15 "
	12-in	0.45 "
	Gatling ½-in.	
	" 1-in.	
Depth of grooves..	3-in.	0 075 in.
	3½-in.	0.075 "
	4½-in	0.075 "
	10-in.	0.09 "
	12-in.	0.09 "
	Gatling ½-in.	0.01 "
	" 1-in.	0.01 "

Twist of grooves..	3-in.	Uniform	1 turn in	10 ft.
	3½-in	"	"	12 "
	4½-in	"	"	15 "
	10-in	"	"	50 "
	12-in	"	"	60, 70 or 80 ft
	Gatling ½-in.	"	"	42 in.
	" 1-in.	"	"	6 ft.

Width of lands....	3-in.........	"	.... 0.5 in
	4½-in.......	"	.... 0.6 "
	10-in........	"	.... 0 7 "
	12-in........	"	.... 0.75 in.
	Gatling 1½-in	"	....
	" 1-in...	"	....

PART I. SECTION III.

ON HOWITZERS.

1. *What is a* Howitzer ?

A piece, of larger calibre than a gun of like weight, mounted in a similar manner, and firing at shorter ranges the same projectiles except solid shot.

2. *How are howitzers denominated?*

Either by the weight of the *solid* shot they would carry, or by the diameter of the bore in inches.

3. *Name the howitzers employed in our service.*

* 24-pdr. Flank Defence, diameter of bore 5.82 inches ; 8-in., diameter of bore 8 inches ; and 12-pdr. Mountain howitzer, diameter of bore 4.62 inches.

4. *Which of these have chambers?*

The 24-pdr. Flank Defence ; and the 12-pdr. Mountain howitzers. These are pieces of the old pattern.

5. *What form of chamber have these howitzers?*

That of a cylinder.

6. *How is it united with the cylinder of the bore?*

By a conical surface.

7. *Describe the bore of the 8-in. howitzer.*

* See Note to the answer to question 13, page 9.

It is a cylinder terminating at the bottom in a semi-ellipsoid.

8. *What advantages are gained by the employment of howitzers?*

They project larger shells than the guns with which they are associated, are well adapted for ricochet fire, the destruction of field works, breaking down palisades, and setting fire to buildings.

9. *What projectiles are used with howitzers?*

Shells usually, spherical-case, canister, grape and carcasses.

WEIGHTS AND DIMENTIONS OF HOWITZERS.

	8-inch.	12-pdr. Mountain.	24-pdr. Flank Defence
Weight, in pounds	2600	220	1476
Preponderance in pounds	380.00	30.00	70.00
Extreme length, in inches	60.00	37.21	69.00
Length of bore, in diameters	5.81	*6.10	*9.15
Diameter of chamber, in inches	......	3.34	4.62
Length of do do	......	2.75	4.75
Semi-axis of ellipsoid (bottom of bore), in inches	6.00	......	.....

* Exclusive of chamber.

10. *What is the natural angle of sight in the 8-in. and 24.pdr. Flank Defence howitzer?*

One degree.

11. *What is it in the 12-pdr. Mountain howitzer?*
Thirty-seven minutes.

PART I. SECTION IV.

ON MORTARS.

1. *What is a* MORTAR?

The shortest piece in service, the diameter of the bore being very large in proportion to its length. It is employed to fire large hollow projectiles under great angles of elevation.

2. *What are the principal advantages obtained by the employment of mortars?*

Reaching objects by their vertical fire—such as a town, battery, or other place—whose destruction or injury cannot be effected by direct or ricochet fire; dismounting the enemy's artillery; setting fire to and overthrowing works; blowing up magazines; breaking through the roofs of barracks, casemates, &c.; and producing havoc and disorder amongst troops.

3. *What do you mean by vertical fire?*

That produced by firing under high angles of elevation, in contradistinction to *horizontal fire*, or the fire of guns or howitzers under low angles.

4. *What are its advantages?*

The shell having attained a great elevation, descends with great force on the object, in consequence of the constant action of the force of gravity on it.

5. *Why are mortars constructed stronger and shorter than other pieces?*

Because greater resistance is required in consequence of the high elevation under which they are fired; and were they longer, the difficulty experienced in loading them would become too great.

6. *Name the mortars in use in our service.*

8 and 10-in. siege mortars; 10* and 13-in. sea-coast mortars; and the 24-pdr. Coehorn mortar, diameter of bore, 5.82 inches. A 15-in. mortar has been adopted, but none as yet have been constructed.

7. *Have any of these mortars chambers?*

Yes, the 24-pdr. Coehorn.

8. *What form of chamber has it?*

That of a frustum of a cone, superior diameter, 3 inches, and inferior, 2 inches.

9. *What is a chamber of this form called?*

A Gomer chamber.

10. *Describe the bore of the other mortars.*

It is a cylinder terminating at the bottom in a semi-ellipsoid.

11. *What is the form of these mortars?*

The *breech* is hemispherical with a ratchet cast on it to give elevation and depression by a lever acting in the ratchet, the *chase* is cylindrical, and the trunnions, instead of being attached to the breech as in the Coehorn and other old pattern mortars, are opposite the centre of gravity, thus doing away with preponderance.

12. *How are mortars designated?*

Usually by the diameter of the bore in inches.

13. *How are mortars mounted?*

* See NOTE to the answer to question 13, page 9.

The 24-pdr. Coehorn on a bed of wood, the others on beds of wrought-iron.

14. *What is the object of mounting mortars on beds in preference to wheel carriages?*

On account of the high elevation at which they are usually fired, when the recoil, instead of forcing the piece backwards, tends to force it downwards, and this tendency becomes so great at the higher angles that no wheel-carriage could long sustain the shock.

WEIGHTS AND DIMENSIONS OF MORTARS AND MORTAR BEDS.

	Sea-coast.			Siege.		
	15-inch.	13-inch.	10-inch.	10-inch.	8-inch.	24-pdr. Coehorn.
Weight of mortars, in pounds......	....	17120	7300	1900	1010	164
do. beds, do.	....	4140	2456	1313	900	132
Entire length of each mortar, in inches	....	54.6	47.5	28.00	22.00	16.32
Length of bore of each mortar, in diameters........................	....	2.7	3.25	2.05	2.00	*1.51
Length of chamber, in inches........	....	.....	.....	.....	.....	4.25
Semi-axis of ellipsoid (bottom of the bore) in inches....................	....	9.00	7.50	7.50	6.00	.....

* Exclusive of chamber.

15. *What was the* EPROUVETTE, *and for what was it used?*

It was a small bronze mortar, its chamber being a cylinder whose diameter was 1.5 inches, used for determining the relative strength of gunpowder.

16. *To what purpose was a stone-mortar applied?*

To throw stones a short distance, from 150 to 250 yards; and also 6-pr. shells from 50 to 150 yards.

NOTE. — The firing of 6 or 12-pdr. shells from mortars of large calibre supersedes the use of the stone-mortar. To fire these shells from such mortars we employ a strong tub or half barrel, provided with two strong rope handles, and with two additional bottoms, to the lower of which a block of light, dry wood, of the diameter and length of the bore, is nailed, the end of the block next the charge being covered with sheet iron. The fuzes of the shells are cut, driven, uncapped, and the shells placed in tiers in the barrel, the fuzes turned down. The last tier is covered over with hay, which is rammed to keep the projectile in place. After the charge of powder is put in the mortar, and the proper elevation and direction given, the barrel or tub, loaded, is raised by the handles, the block wiped clean, and introduced into the bore and set home.

17. *In what manner were the stones disposed in this mortar?*

They were put into a basket fitted to the bore, and placed on a wooden bottom which covers the mouth of the chamber.

18. *What use is made of Coehorn mortars?*

They are fired either from behind entrenchments, like other mortars, or they may accompany troops in effecting lodgments in towns and fortified places.

19. *What kind of projectiles are thrown from mortars?*

Shells, fire-balls, and carcasses.

20. *How rapidly may siege mortars be fired?*

Twelve times per hour usually; and in case of need with greater rapidity.

PART I. SECTION V.

SEA-COAST ARTILLERY.

1. *What pieces constitute our sea-coast artillery?*

* 13, 15 and 20-in. smooth bores; * 10 and 12-in. rifles, and 10, 13 and * 15-in. mortars.

NOTE.—The 24-pdr. flank defence howitzer, although no longer belonging to the *system* (see Note at bottom of page 9), is still employed in several of our forts on the seaboard.

2. *How are sea-coast pieces mounted?*

On barbette, casemate and flank casemate carriages; and the carriage upon which the mortar is mounted—called its *bed*. These carriages do not subserve the purpose of transportation,

3. *What disposition should be made of heavy rifle and smooth bore cannon in a fortification?*

The heaviest rifle cannon should be placed on the salients and flanks having an enfilading fire on a channel. Heavy smooth bore pieces should occupy the curtains and faces which bear directly on the channel.

4. *How is the 24-pdr. flank defence howitzer employed?*

In the defence of the ditches. Single or double shotted canister should be fired from it. The Gatling gun has been recommended as a desirable auxiliary in special cases.

* See NOTE to the answer to question 13, page 9.

5. *May field pieces be usefully employed in a fortification?*

Yes; particularly the 12-pdr., to prevent a landing, or to fire in close engagements at the rigging and boats of vessels.

6. *What kinds of fire are mostly employed?*

Direct, ricochet and *plunging* fires. The first should be used when the surface of the water is rough, and the accuracy of the rebound cannot be depended on. In aiming at a vessel with *direct* fire, the piece should be pointed at the water line.

7. *What is considered the range of effective* DIRECT *fire?*

About one mile and a quarter.

8. *What is intended to be effected by sea-coast mortars?*

To strike the decks of vessels, penetrating to the bottom and causing them to sink.

PART I. SECTION VI.

SIEGE ARTILLERY.

1. *What pieces constitute our siege artillery?*

4½-in rifle gun; 8-in. howitzer; 8, 10-in. and 24-pdr. Coehorn mortars.

NOTE.—The Parrott 30-pdr. (4.2-in.) rifle gun so extensively employed in our service, is not a *regulation* gun, and does not, consequently, belong to our siege system. [For description of this gun see page 180.]

2. *How are siege-guns mounted?*

Usually on travelling-carriages, with limbers.

3. *Of what number and kind of pieces is a siege-train composed?*

This must altogether depend on circumstances; but the following general principles may be observed in assigning the proportion of different kinds and calibres, and the relative quantity of other supplies, for a train of 100 pieces:—

GUNS.	About three-fifths the whole number	60
HOWITZERS.	One-fourth	25
MORTARS.	10-in. siege, one-eighth	12
	8-in. siege	3
COEHORN MORTARS.	In addition to the 100 pieces	6

CARRIAGES.

For guns and howitzers, one-fifth spare	102
For 10-in. mortars, one-sixth spare	14
For 8-in. mortars	4
Mortar-wagons, 1 for each 10-in. mortar and bed, and for three 8-in. mortars and beds	14
Wagons for transporting implements, intrenching and miners' tools, laboratory tools and utensils and other stores, each loaded with about 2,700 lbs., say	140
Carts (carrying balls, &c., on the march)	50
Park battery-wagons, fully equipped	28
Park forges, fully equipped	8
Sling-carts, large	5
" hand	4

DRAUGHT HORSES.

For each	gun and howitzer, with its carriage	8
"	Spare gun-carriage	6
"	Mortar-wagon	8
"	Battery-wagon	6
"	Forge	6
"	Cart	2
"	Sling-cart, large	2
Spare horses		1-10th

Total, about 1,900 horses.

PROJECTILES AND AMMUNITION.

FOR GUNS.
- Solid shot, 1,000 to each piece.
- Grape and canisters strapped, 20 rounds to each piece.
- Spherical-case strapped, 20 rounds to each piece.
- Shells, 40 rounds to each piece.

FOR HOWITZERS.
- Shells, 800 to each 8-in. howitzer.
- Canisters strapped, 5 to each.
- Spher. case strapped, 20 to each.

FOR MORTARS.
- 600 shells to each 10-in.
- 800 " " 8-in.
- 200 " " Coehorn.

Gunpowder, in barrels. 300,000 lbs.

Computing for each 4½-in. solid shot about one-tenth the weight of shot.

" " shell, grape, canister and case, one-tenth the weight of shot.

Computing for each round of howitzer ammunition, 5 lbs.
" " round of 10–in. mortar ammunition, 7 lbs.
" " round of 8–in. mortar ammunition, 3 lbs.
} including charge of shell.
" " round Coehorn mortar ammunition, ½ lb.

4. *What is the best position for guns in order to make a breach?*

On the glacis, within 15 or 16 feet of its crest; but if the foot of the revetment cannot be seen from thence, the guns must be placed in the covered-way, within 15 feet of the counterscarp.

5. *In what manner should the fire of siege-guns be conducted in order to form a breach?*

1st. Make a horizontal section the length of the desired breach along the scarp, at one-third its height from the bottom of the ditch, and to a depth equal to the thickness of the wall.

2d. Make vertical cuts through the wall, not further than ten yards apart, and not exceeding one to each piece of ordnance, beginning at the horizontal section and ascending gradually to the top of the wall.

3d. Fire at the most prominent parts of the masonry left standing; beginning always at the bottom and gradually approaching the top.

4th. Fire into the broken mass with howitzers until the breach is practicable.

6. *How long would it take to make a breach of 20 to 30 yards in length?*

The time required to make a breach depends on the size of the breach to be made, the material of the scarp

the number of guns, &c. For a breach of 20 to 30 yds. in length, at 40 yds. from the battery, 1500 shot of large calibre will be required, but when the battery is at a greater distance, a greater number of projectiles will be necessary, on account of the diminished accuracy and penetration. Thus at 500 or 600 yds. 9000 to 10,000 may be needed.

7. *How many discharges can an iron gun sustain?*

An iron gun should sustain twelve hundred discharges, at the rate of twelve an hour; but whatever may be the rate of fire, it is deemed unsafe after that number of discharges. As many as twenty an hour have been made for sixteen consecutive hours.

NOTE.—Experiments at Fort Monroe, Va., prove this to be a safe estimate of the number of discharges an iron gun can sustain, as two new model 10-in. columbiads were fired, with charges of 14 and 18 lbs. of powder, nearly 4000 times each. One of these pieces was cast hollow and the other solid under the direction of Captain Rodman of the Ordnance. In consequence of the action of the elastic force of the gases, due to the combustion of the powder, in enlarging the vent, the pieces had new vents bored in them some 7 or 8 times.

PART I. SECTION VII.

ON FIELD GUNS AND BATTERIES.

1. *What pieces constitute our Field Artillery?*

3 and 3½-in. rifle guns; *½-in. and *1-in. Gatling; and the 12-pdr. smooth bore.

* These calibres, by a recent decision of the War Department, are to be superseded by one of .45-inch, the same as that of the new rifle musket.

NOTE.--The 12-pdr. mountain howitzer was formerly classed as a field piece, but in the new Field Artillery tactics it is discarded as such. The model for the $3\frac{1}{2}$-in. gun was adopted in 1870. It is to be made of wrought iron or bronze. No *particulars* of this gun have been given.

2. *What proportion of artillery should be allotted to an army in the field?*

The proportion of artillery to other troops varies generally between the limits of one and three pieces to 1000 men, according to the strength of the army, the character of the troops composing it, the strength and character of the enemy, the nature of country which is to be the theatre of the war, and the character and objects of the war.

The army commanded by the Archduke Charles in the campaign of Aspern, Esling and Wagram, consisted of 125,000 men, to whom were attached eighteen batteries of brigade, thirteen of position, and eleven of horse artillery, being a proportion of one piece to 260 men. The French army for the invasion of Russia consisted of 400,000 infantry, 60,000 cavalry, and 1200 cannon—one piece to 383 men. General Dombrowski's division of 6000 men on the Beresina in 1812, had twenty cannon—one piece to 300 men. The Prussian contingent under General D'Yorck, of the grand French army for the invasion of Russia, was 20,000 men and sixty cannon—one piece to 333 men. In 1813, Napoleon had one hundred and forty cannon to 30,000 men—one piece to 214 men. In 1815, his army consisted of 130,000 infantry, 20,000 cavalry, 300 cannon—one piece to 500 men. Marshal Beresford, at the battle of Albuera, had 29,000 men and thirty-two cannon—one piece to 906 men. Marshal Soult, in the same action, had 23,000 men and forty cannon—one piece to 575 men. The French armies united on the Tormes, in 1812, amounted to 80,000 men and two hundred cannon—one piece to 400 men. The British army in the great Hampshire campaign, 1871, consisted of 30,233 men and ninety cannon—one piece to 325 men.

3. *What is a field-battery?*

A certain number of pieces of artillery so equipped as to be available for attack or defence, and capable of accompanying cavalry or infantry in all their movements in the field.

4. *How many pieces are allotted to a field-battery?*

Four guns for *instruction* or for the *march*, or in a state of *preparation for active service*, and *six* for *war*.

5. *How is field or light artillery divided?*

Into *Mounted Artillery* which usually serves with infantry, and *Horse Artillery*, which ordinarily serves with cavalry.

NOTE.—The *foot*, or *heavy artillery* of an army in the field, consists of such artillery troops as man the guns of position and the siege train, and of those which escort and guard the ammunition and supply trains of the artillery.

6. *In what respect does a battery of horse artillery differ from one of mounted artillery?*

The main difference consists in the cannoneers in a battery of horse artillery being mounted; in rapid evolutions of mounted artillery they are conveyed on the carriages.

7. *What is the composition of a* MOUNTED BATTERY *on the war establishment?*

Kind of battery.		12-Pdr.	3-in. rifle.
GUNS.	12-pdrs. mounted	6	....
	3-in. "	....	6
CAISSONS		12	6
TRAVELLING FORGES		1	1
BATTERY WAGON		1	1
Whole No. of carriages with a battery		20	14
Ammunition for 6 pieces.	Solid shot	288	108
	Canister	96	108
	Time shell	....	108
	Shell	96	....
	Percussion shell	....	756
	Case	288	216
	Total No. of rounds	768	1296
Draught horses.	6 to each carriage	120	84
	Spare horses, 1-12	10	7
	Total	130	91

NOTE.—Horse batteries on the war footing have *four* guns. A battery of Gatling guns has from six to ten pieces. No. of solid shot for each $\frac{1}{2}$-in. Gatling gun is 10,200, and for each 1-in. Gatling gun is 2592. Ammunition is issued from the Arsenals, prepared for immediate use, and is packed in boxes, which are painted on the outside different colors to indicate the contents. Those for solid shot are painted *olive*; for shell, *black*; for case shot, *red*; for

canister, *light drab.* The kind of ammunition is marked in white letters on each end. The place and date of fabrication are marked on the inside of the cover. The paper *caps* for shells are stained *black*; for spherical case *red*; for shot *not colored.*

8. *What is the composition of a battery of mountain howitzers?*

Howitzers	6
Gun-carriages	7
Ammunition-chests	36
(48 rounds for each howitzer.)	
Forge and tools, in 2 chests	1
Set of carriage-makers' tools, in 2 chests . . .	1
Pack saddles and harness	33
Horses or mules	33

9. *What composes the* FIELD-PARK?

The spare carriages, reserved supplies of ammunition, tools, and materials for extensive repairs, and for making up ammunition, for the service of an army in the field, form the *Field-Park*, to which should be attached also the batteries of reserve.

10. *What determines the quantity of such supplies?*

It must depend in a great measure on the particular circumstances of the campaign.

11. *How is the ammunition which cannot be transported by the batteries carried?*

With the park; in caissons, or in store-wagons.

12. *Do any other carriages and stores form part of the Field-Park?*

Yes; *spare gun-carriages*, one to each field battery,
Travelling Forges, } one or more of each.
Battery Wagons, }

Spare spokes, 50 to each battery,
Spare fellies, 20 to each battery,
Spare harness, in
Horse-shoes and nails, boxes.
in store wagons.

Gunpowder, saltpetre, sulphur, charcoal, laboratory paper, percussion-caps for small arms, friction primers for cannon, stuff for cartridge bags, woollen yarn, cotton yarn, glue.

13. *Are any other pieces ever used for field service?*

Yes; sometimes the 4½–in. siege gun, and the 8–in. siege howitzer.

NOTE.—The 20-pdr. Parrott gun was used during the war of the rebellion as a heavier field gun as well as for batteries of position.

14. *For what particular service are the different pieces most suitable?*

The siege pieces for batteries of position; the field pieces for following the movements of infantry and cavalry.

NOTE.—These siege pieces should be placed on the weakest points of a line, and on heights which either form a key to the position, or from whence the greatest and longest continued effect may be produced.

15. *What are the peculiar advantages of Horse Artillery?*

Possessing, from their lighter construction and mounted detachments, much greater locomotive powers than other field-batteries, they are especially adapted for following the rapid evolutions of cavalry, for sudden attacks upon particular points, and for supporting the advance or covering the retreat of an army.

16. *How is a field gun mounted?*

Upon a four-wheel carriage, which answers for its transportation as well as for its service, similar to a siege carriage, but lighter, and the limber carrying an ammunition chest.

17. *Where should a battery be placed before the commencement of an action?*

As much as possible under cover, by taking advantage of banks, hollow-ways, buildings, woods, &c.

18. *Is it advisable to move a battery at once into position in the field?*

No; but if unavoidable, it should be masked as much as possible until ordered to open its fire.

19. *How should a battery be masked?*

If practicable, by covering it with cavalry, in preference to infantry, as the former does it more effectually, and is sooner moved out of the way.

20. *In commencing an action, how should the fire of a battery be directed?*

When the enemy is in line, the fire should be directed over the whole line, and not upon the real points of attack; but when in column, ready to advance, it should be concentrated upon the real points of attack.

21. *How should batteries be placed in relation to the troops with which they are acting?*

Upon the flanks of a line, but at such a distance as not to impede its movements, and at the same to be unfettered in their own; the artillery may thus represent the faces of a bastion, and the line of troops the curtain.

22. *Is the front of a line of troops an advantageous position for a field-battery?*

On the contrary, it is the worst possible, as offering a double object to the enemy's fire, and greatly obstructing

the movements of the troops; while a position in rear is nearly as bad, as the fire might seriously injure, or at least, greatly disquiet them.

23. *In supporting an attack what precautions are necessary?*

The battery should be carefully kept clear of the intended line of march of our own troops, and such points occupied as may afford the greatest annoyance to the enemy.

24. *How should batteries be disposed with regard to the enemy's troops?*

Generally so as to secure a cross fire on his position, and on all the ground over which he moves to the attack, endeavoring to take him at all times in the direction of his greatest dimensions; that is, obliquely or in flank when in line, and in front when formed in columns. Moderate heights, commanding as much as possible the surrounding country, should always be taken advantage of, but not such as may prevent operations in advance if required.

25. *Is it imperatively ne essary to confine positions for fi.ld-batteries to the flanks of a line?*

When, from particular circumstances, the front of the army is too extended, and unavoidably divided into two lines, it may become necessary to place one or more batteries in the centre, if those on the flanks are unable to sweep the whole front; but great care must be taken not to impede the advance or retreat of the troops when required.

26. *Should the fire of field batteries be carried on at the same uniform rate?*

Certainly not; the destruction of the enemy being the object, it follows that at distant ranges, a greater degree of care is required in pointing the guns; the fire is slow

and steady, and increasing in rapidity as the enemy advances, without however impairing its precision.

27. *Should the fire of field-batteries be carried on in salvoes or otherwise?*

Never in salvoes; but in a regular manner, well sustained, and with distinct intervals between every round, commencing slowly, and increasing in rapidity as the range diminishes.

28. *Is the fire of batteries more efficacious when dispersed than when concentrated?*

The effects of the fire will be in proportion to the number of guns brought together, and therefore, in order to strike a decisive blow, this should at once be done.

29. *What projectiles are used with field guns?*

With the 12-pdr., solid shot, shells, spherical case and canister; with the 3-in. gun, solid shot, canister, time shell, percussion shell and case; with the ½-in. Gatling, solid shot; and with the 1-in. Gatling, solid shot and canister.

30. *At what distance from the enemy should the several kinds of projectiles be employed with field battery pieces?*

Solid shot from 350 yards and upwards; spherical case from 500 or 600 up to 1000 yards, although it may be used within the first range; and canister within 350 yards or up to 400 against extended formations, the rapidity of its fire increasing as the range diminishes. Within 200 yards, two canister projectiles with a single cartridge do most execution.

31. *Upon what does the kind of projectile to be used depend?*

Upon the character of the object fired at. *Percussion-shell* is employed against troops in line or column, and against artillery; in opening fire, it is always used to get the range, the puff of smoke from the explosion of the

projectile, showing the exact striking point. The *time-shell*, or shell with the time-fuze, is used against earth-works, buildings, block-houses, shipping, and combustible materials; the fuze is cut long. *Case-shot* is chiefly used against troops, and should burst from 50 to 75 yards in front of the object, and from 15 to 20 feet above it. Neither shells nor case should be fired at rapidly advancing bodies, as for instance, cavalry charging. As batteries can no longer move up to short range of troops and open fire with *canister*, its use offensively is entirely ended. On the defensive, it will oftenest come into play in repelling charges, and assaults upon earthworks or fortified positions. *Solid shot* is employed for percussion and penetration; with rifled guns it may be dispensed with, *Case-shot* without fuzes or with fuzes uncut, being used in its stead. When necessary to fire over other troops, solid shot or shell (preferably percussion), should be used; case or canister never.

32. *For what are Gatling batteries best suited?*

For defensive operations; in action they are posted, as a rule, to defend important positions of the line; offensively, in attacks of intrenched works, etc., when they can fire over the assaulting columns, they may be used to silence the enemy's guns at the moment of attack, and to cover the retreat of the assailants, if driven back. If practicable, these batteries should be always posted under cover. They are peculiarly fitted for the defense of intrenched positions, villages, roads, defiles, and bridges; for covering the embarkation or debarkation of troops, or the crossing of streams. They should be employed for ordinary street-fighting.

33. *What number of rounds can be fired from a 3-in., or 12-pdr. in a minute?*

Two solid shot or case, or three of canister.

34. *Why are more rounds of canister fired in a minute than of solid shot or case?*

Because the latter are fired at greater distances than canister, and require the piece to be carefully aimed, thus requiring more time.

35. *What is the smallest number of guns that may with safety be employed in the face of an enemy?*

Never less than two, in order to secure a continuous fire and mutual support.

36. *Is the practice of employing field-batteries against those of the enemy recommended?*

Only under peculiar circumstances; as for instance, when his troops are well covered and his guns exposed, or their fire very destructive.

Their fire should be directed principally against columns of attack, and masses, or upon positions which are intended to be carried.

37 *In what time could a battery come into action in the field?*

It could come into action and fire one round in 25 seconds, timing from the order "action front," to the discharge of one piece.

38. *Suppose cavalry to be advancing to attack infantry, and first observed at the distance of a mile, passing over the first half mile at a trot; the next quarter of a mile at the manœuvring gallop, and the remaining distance at an increased gallop, terminating with the charge; occupying altogether about six minutes: during the last 1500 yards of their advance how many rounds per piece might a battery fire in that time?*

Eleven rounds with effect, thus:

From 1500 to 650 yards . . .	3′ 32″—case . . .	7
" 650 to 350	0′ 48″—solid shot . .	2
" 350 to close quarters .	0′ 34″—canister . .	2

39. *What number of rounds could a battery fire against infantry, supposing them to pass over* 1500 *yards in about* 16¼ *minutes?*

Thirty-six rounds with effect, viz.:

From 1500 to 650,	quick step	9′ 45″—case .	19
" 650 to 350	"	3′ 50″—solid shot .	7
" 350 to 100	"	2′ 30″—canister. .	8
" 100 to close quarters.	double time and the charge.	0′ 40″—can.	2

40 *Should the enemy attempt to force the passage of a river, what is the best position for artillery to oppose it?*

Wherever the best cross fire can be obtained in order to obstruct and harass him as much as possible; and if he has succeeded in passing over any portion of his troops, it should be directed against their formation.

41. *When the enemy is making the passage of a river in retreat, where should your guns be posted?*

In such a position as to bear upon the batteries that cover the retreat, and also upon his bridges.

42. *In forcing the passage of a river what is the most advantageous position for artillery?*

The bridge being generally laid in a re-entering angle, batteries should be posted on each side of the bridge, and far enough from it to secure a cross-fire on the opposite bank.

43. *Should the indiscriminate expenditure of ammunition be permitted in the field during action?*

Upon no account; ammunition should at all times be

carefully husbanded, particularly at the commencement of an action, as the want of it at the close may decide the fate of the day; it should also be sparingly used in skirmishes and minor affairs, especially when at a distance from supplies, or in anticipation of a general action.

44. *When should the reserve be employed?*

When a particular point of the line requires additional support, a favorable position is to be seized, an impression has been made on the line by the enemy, a forward or retrograde movement is in contemplation, or when a determined attack is to be made on him, then the reserve should come up and take part in the action; and it is of the utmost importance that this should be done as expeditiously as circumstances will permit.

45. *Where should the reserve be placed previous to an engagement?*

In rear with the second line, out of the range of shot, and as little exposed as circumstances will admit, but always in such a position as to have ready access to the front or rear.

46. *Should guns be lightly abandoned before an enemy?*

Never until the VERY LAST EXTREMITY. An artilleryman must never forget that his gun is his proper ARM; that here lies his strength; that here is his post of honor and duty; also, that the LAST DISCHARGES are ALWAYS THE MOST DESTRUCTIVE, and MAY POSSIBLY INSURE THE SAFETY OF THE WHOLE ARMY, OR TURN THE TIDE OF VICTORY IN THEIR FAVOR.

47. *What is the position for cavalry when placed in support of a battery?*

On its flank, about the distance of 100 yards, and as much concealed as possible.

PART II. SECTION I.

POINTING GUNS AND HOWITZERS.

1. *What is meant by the term* POINTING *a piece?*

To point a piece, is to give it such a direction and elevation, or depression, that the projectile may strike the object.

2. *When a projectile is fired from a piece, by how many forces is it acted on?*

By three.—1st. The impulsive force of the powder which urges it forward.

2d. The resistance of the air, which tends to stop it

3d. The force of gravity, which causes it to descend.

3. *Why is it necessary to give a certain degree of elevation to a piece?*

Because a projectile describes under the action of the above forces a curve called a trajectory, which is situated below the prolongation of the axis of the piece, the extent of its departure from *this line* increasing with the time of flight. Therefore, the more distant the object, the greater must be the elevation to enable the projectile to reach it.

4. *How is the direction given to a gun or howitzer?*

By directing the line of metal upon the object.

5. *How is the elevation or depression given?*

The elevation or depression, which depends upon the charge, the distance, and the position of the object above or below the battery, must be ascertained from tables or by experiment, and the proper degree given by means of instruments.

6. *When will the object be struck by merely directing the line of metal upon it?*

But in one case,—when it is at point-blank distance.

7. *How must the line of metal be directed for all ranges less than the point-blank range, in order to strike it?*

So as to pass below the object.

8. *Give a simple rule for firing at objects within point-blank.*

Add to the point-blank range the difference between it and the required range, set the scale to the elevation corresponding to this sum, as shown by tables of firing. Then aim the gun directly at the object; now apply the scale, and observe where the visual ray of the scale, or line of sight or aim strikes the ground, and having noted this point, aim the gun directly at it.

Reasons for this rule. When the gun is aimed directly at the object, the *elevation is* too great by *that* to which the scale is set. *The line of sight or aim* of the scale therefore determines a point on the ground corresponding to the required depression. This supposes the elevation to increase *uniformly* with the range, and the rule gives only approximate results.

Likewise, if the *elevation* be less than can be determined directly by the breech sight (as for instance, if the lowest mark on the scale be 2°, and the desired elevation be ½°), sight the piece at the *lowest degree* on the scale, then add to *this* its excess over the required elevation, run the slide up to this number, and note the point or object on the ground which the new line of sight strikes, then run the slides back to the *lowest degree* on the scale and aim at the point last obtained and we have the desired elevation.

9. *How must the line of metal be directed for ranges greater than the point-blank range, in order to strike it?*

Above it.

10. *When the line of metal passes over the object, what instruments must be employed for giving the proper elevation?*

The gunner's quadrant, or the breech-sight.

11. *How is the quadrant used?*

After the direction has been given, the quadrant is applied, either by its longer branch to the face of the piece, or this branch is run into the bore parallel with the axis, or it may be applied to the upper surface of the lock-piece, making the allowance due to its inclination with the axis of the piece, which ought to be previously determined, and the elevating screw turned, or the quoin adjusted, until the required degree is indicated.

12. *How is the breech-sight used?*

It is first set to the elevation corresponding to the distance as given by tables of ranges; it is then applied to the highest point of metal on the base-ring, or placed in the socket on the breech, and by the elevating screw, or quoin, the notch of the breech-sight, the highest point on the swell of the muzzle or front sight, and the object, are brought in the same line.

13. *What is a line thus determined called?*

An artificial line of sight.

14. *In the absence of instruments, how may the elevation be given?*

By placing one or more fingers of the left hand upon the base-ring, perpendicular to the axis, and using them as a breech-sight.

NOTE.—In practice, it is well to fire two or three shots to determine the range experimentally, as it is affected by divers causes

15. *Should the line of metal be always directed in the vertical plane passing through the object?*

No; as in practice there are circumstances (as, for in-

stance, a strong wind blowing across the field of fire) which will cause a ball to deviate from this plane, it follows that to strike the object, in such a case, the line of metal must be directed to its right or left; the gunner judging of the distance by observing the striking of the projectile.

NOTE.—The excentricity of a spherical projectile causes it to deviate. If the projectile be so placed in the bore that its centre of gravity be to the right of the axis, the deviation will be to the right; if to the left of the axis, the deviation will be to the left; if placed above, the range will be increased, and if below, diminished. The rotation of the earth on its axis is another cause, arising from the fact that points of the earth's surface not in the same parallel of latitude have different rotary velocities, and that a projectile carries with it the velocity of the point of departure. It is found that a projectile, from this cause, will deviate to the right, in the northern hemisphere, no matter in what direction it is fired, the distance depending on the latitude of the place, and on the range and time of flight. A 12-inch shell of 200 lbs. weight, fired under an angle of 45°, and having an initial velocity of 900 feet, will deviate 15 to 20 feet to the right of the object. Rifle-projectiles have a deviation peculiar to themselves called *drift*, which is a constantly-increasing divergence from the plane of fire, in the direction of the twist of the grooves. If the bore be grooved with a right-handed twist, so that the projectile rotates from left to right, the drift is to the right; if the twist be left-handed, the drift is to the left. The twist being right-handed in all rifled guns in our service, the deviation due to drift is corrected by pointing more or less to the left, depending upon the range.

16. *Is the line of metal a permanent line under all circumstances?*

No; in batteries for garrison and sea-coast defence, where the platforms are fixed, the line of metal may be considered as nearly permanent; but with siege guns, which are mounted on travelling carriages, the wheels of which are liable to vary in position from unevenness of ground, or unequal settling in newly constructed platforms,

this line is constantly changing. It approximates the higher wheel in proportion to the difference of level between the wheels; and hence, to secure the greatest accuracy of fire it must be frequently verified; the old marks, if not found correct, should be erased and new ones substituted.

17. *When the notches or sights, which are sometimes made upon the base-ring and swell of the muzzle in field guns, for aiming the piece are used, how is the error of direction remedied when the wheels are not in the same level?*

The piece must be aimed more or less to that side which corresponds to the higher wheel, according to the inclination.

NOTE.—For instance, supposing the left wheel to be the higher wheel, the *marked line of sight* prolonged passes to the left of the vertical plane of fire, and if the piece be aimed by that, the projectile would go too far to the *right*, or on the side of the lower wheel.

18. *When the elevation or depression has once been ascertained for any given distance, how may the firing at that distance be facilitated?*

By noting some point on the elevating screw or quoin; adjusting some fixed measurement from a point on the stock to another point on the under side of the breech; or by a chalk mark drawn across the face of a trunnion and its corresponding cheek.

19. *When firing either within or beyond point-blank range, may remarkable points on the ground be taken advantage of, in order to furnish an object to aim at?*

Yes; some fixed object may often present itself which will serve as a point upon which to direct the line of metal. No means should be neglected that may tend to secure accuracy of aim; for the shot that is thrown away by carelessness in pointing, had better not be thrown at all.

20. *How may precision of fire be secured at night?*

When a fixed object is to be fired at by night, the piece should be directed during the day, and two narrow and well-dressed strips* of wood laid on the inside of the wheels, and two others outside of the trail of a siege carriage, and nailed or screwed to the platform. In case of a barbette carriage, the traverse wheels should be chocked in the proper position. To preserve the elevation, measure the height of the elevating screw above its box, or take the measure between a point on the gun, and another on the stock; cut a stick to this length and adjust the gun on it at each fire.

21. *Should night-firing with* GUNS *be limited?*

Yes; it should be limited to a small number of rounds, as it consumes ammunition to little advantage.

* To prevent injury to the strips from the recoil, they should be nailed at such a distance from the carriage that the space can be filled up with a strip that can be removed before firing.

PART II. SECTION II.

POINTING MORTARS.

1. *What is the general rule for pointing mortars?*
First give the elevation, and then the direction.

NOTE.—In sea-coast mortars mounted on beds with eccentric axles, the *direction* should be first given and afterwards the *elevation*, as the *latter* would be changed by throwing the eccentric axle out of gear.

2. *How is the elevation given?*
The quadrant is applied to the face of the piece and the breech raised or lowered, until the required number of degrees is indicated, by embarring with the iron elevating bar, through the fulcrum, in the ratchets of the mortar.

3. *Are the same means employed for giving mortars their direction as those which are used with guns and howitzers?*
No; because mortars are usually masked from the object to be struck, by an epaulment or parapet.

4. *To what are all the methods employed for giving the direction to mortars reduced?*
To determining practically two fixed points, which shall be in line with the piece and the object, and sufficiently near to be readily distinguished by the eye. These points being covered by the plummet, determine a vertical plane, which, when including the line of metal, becomes the plane of fire.

5. *What is the simplest manner of directing the mortar?*

By means of *pointing-wires.*

6. *Describe this method.*

The two fixed points required are determined by planting two wires upon the epaulment, one upon its crest, and the other about a yard in advance of it, both as nearly as possible in the vertical plane passing through the centre of the platform and the object. The points being thus established, the direction is given to the mortar, by causing a plummet held in rear of it, to cover the wires and the line of metal.

7. *In what respects is this method defective?*

Both in accuracy of aim, and the liability of the wires being deranged by the shots of the enemy or by other causes.

8. *Give a better method.*

By means of *pointing-stakes*, by which one of the fixed points is established upon the crest of the parapet or at the foot of the interior slope, and another in rear of the piece. Then by a cord called the *pointing-cord*, stretched between these two points, with the plummet suspended from it, a vertical plane is determined with which the line of metal is made to coincide.

9. *How are the stakes planted?*

A stake, a foot or more in length, is driven into the crest of the epaulment, as nearly as practicable in the vertical plane of fire passing through the centre of the platform;* sighting by this stake, another long one is planted, three or four feet in front of it, in line with the object. To this stake the cord is temporarily attached,

* When the mortar is mounted on a centre pintle carriage, the vertical plane passing through the *centre of the pintle*, the object to be reached, and the line of metal, determines the plane of fire.

and stretched by the first stake, just grazing it, to a point on the ground, one yard in rear of the platform. At this point a third stake is driven. The cord is removed from the second stake, which may now be taken away, and permanently attached to the first.

10. *How is the mortar directed?*

The cord is stretched to the rear stake, and as near the muzzle band as possible, with the left hand, while the plummet is suspended against it with the right; or the plummet may be attached to the cord, just in rear of the mortar. The line of metal is then brought into the plane of these two lines.

11. *How does it appear that the mortar is thus* PROPERLY *directed?*

Because the cord, the plummet, and the line of metal, are evidently in the vertical plane of fire.

12. *What is done in case the shell should strike constantly to the right or left of the object?*

The pointing cord is shifted to some notch on the *pointing board*, to the right or left, until the shell falls at the desired point.

13. *Describe the pointing board.*

This is a piece of wood one foot long, two or three inches wide, and one inch thick, having a notch cut in the middle of one side, to fit on the stake and which is graduated into equal divisions from its middle. When not in use, the pointing cord may be wound on it.

14. *Describe another mode of planting the* POINTING-STAKES.

The mortar being placed upon the middle of the platform, the gunner mounts upon it, and suspends the plummet in front of the muzzle, covering the object. Where the plummet thus suspended cuts the crest of the epaul-

ment, the first stake is driven. A second stake is then driven in the same line between the mortar and the epaulment. The pointing cord being attached to the first stake and stretched to the rear, over the point where the plummet touches the top of the mortar, determines the point on the ground at which the rear stake is driven. The first stake is then removed, and the cord attached permanently to the second stake.

When the object cannot be seen from the mortar, owing to the interposition of some obstacle, as a parapet or a hill, two persons in sight of each other, one of whom faces the mortar, and the other the object, must by successive changes of position, place themselves in the vertical plane of fire, and at the points thus determined, stakes must be driven, one of which will serve as the object.

15. *How may precision of fire be secured at night with mortars?*

The *direction* is preserved by nailing or screwing two boards to the platform outside of the checks, and the *elevation* by drawing a line across one of the trunnions, or by inserting a wedge-shaped block of the proper inclination below the mortar and the front transom or step.

PART III.

CHARGES.

1. *What is the charge of a piece of artillery?*
The powder with which it is loaded.

2. *In what manner are the charges of mortars regulated?*
The charges vary with elevation; or if the elevation be fixed at any particular angle, they must be determined by the range.

3. *What are the charges for field pieces?*
See Table below.

4. *What are the charges for heavy guns and howitzers?*
See Table, page 70.

5. *What are the greatest charges of the sea-coast, siege, and coehorn mortars?*
See Table, page 70.

6. *What charge is used for projecting fire-balls from mortars?*
One *twenty-fifth* of the weight of the ball.

CHARGES FOR FIELD PIECES.

Piece.	3-in.	3·5-in.	Gatling.		12-pdr.
			Half-inch.	1-inch.	
Powder used	Mortar.	Mortar.	Musket.	Mortar.	Mortar.
Shell.	1 lb.				2.5 lbs.
Case-shot.	1 lb.				2.5 lba.
Canister.	1 lb.			.75 oz.	2.0 lbs.
Solid shot.	1 lb.		70 grs.	.75 oz.	2.5 lbs.

CHARGES FOR HEAVY GUNS AND HOWITZERS.

Piece.	20-in.	15-in.	13-in.	10-in.	12-in. rifle.	10-in. rifle.	4.5-in.	Howitzers. 8-in.	Howitzers. 24-pdr.	Howitzers. Mountain.
Powder used.	Mammoth.	Mammoth.	Mammoth.	Cannon.	Cannon.	Cannon.	Mortar.	Mortar.	Mortar.	Mortar.
	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.
Solid shot........	200	100	....	25	....	....	3¼			
Shell............	....	....	....	....	....	....	3¼	4	2	0.5
Canister.	....	....	....	....	....	....	....	4	2	

GREATEST CHARGES OF SEA-COAST, SIEGE, AND COEHORN MORTARS.

Sea-coast.		Siege.		Coehorn.
13-in.	10-in.	10-in.	8-in.	24-pdr.
lbs.	lbs.	lbs.	lbs.	lbs.
20.	10.	4.	2.	0.5.

PART IV.

RANGES.

1. *What is meant by the* RANGE *of a piece of artillery?*

The horizontal distance from the muzzle to the first graze of the projectile.

2. *How may the range of a projectile be extended without increasing the charge of powder?*

In three modes, viz.: 1st, by raising the piece to a higher level; 2d, by giving its axis greater elevation; 3d, by *eccentric* projectiles, experiments having shown that if the centre of gravity be placed directly above the centre of figure, the range is greatly increased.

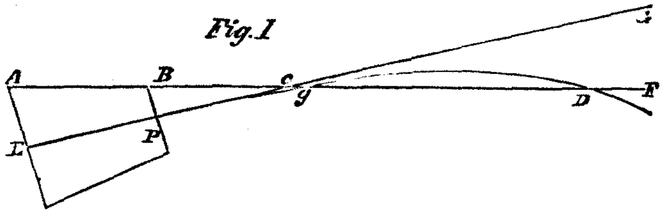
3. *Define* POINT-BLANK RANGE.

The distance from the muzzle of the piece to that point in a projectile's trajectory where it cuts the prolongation of the natural line of sight, a second time, the natural line of sight being horizontal.

NOTE.—In the new artillery tactics, the British definition for point-blank range has been adopted, which is "the distance from the muzzle to the first graze when the axis of the piece is parallel to the horizontal plane upon which the carriage stands."

4. *Explain by a figure, the position of, and relations existing between the line of sight, the line of fire or axis of the piece, and the trajectory, and what the angle of fire, angle of sight, plane of fire, plane of sight, and the point-blank are.*

Fig. 1



A BcF, the line passing through the highest points of the base of the breech and swell of the muzzle, or the muzzle band, or the top of the sight if there be one, is called *the natural line of sight. EPcG* is the *axis of the piece* or *line of fire;* the curved line *PgD*, described by the projectile, is called the *trajectory*, and is entirely below the line of fire, in consequence of the action of the force of gravity giving the projectile a downward tendency. The point D is the *point-blank*, and its distance from the muzzle the *point-blank range. The angle of fire* is the angle included between the line of fire and the horizon. *The angle of sight* is the angle *AcE* made by the line of sight, and the axis of the piece. *The plane of fire* is the vertical plane containing the line of fire. *The plane of sight* is the vertical plane containing the line of sight.

5. *Mention some of the causes which vary the point-blank range.*

The form of the cannon; the weight or force of the charge; the diameter and weight of the projectile; and the inclination of the line of sight to the horizon.

6. *Why has the form of the cannon an influence on the point-blank range?*

Because as the difference between the diameters of the

breech and muzzle become greater, the angle of sight, $BcP = GcF$ (see fig.) increases, and the point-blank D is removed farther off; on the contrary, as the diameters approach to an equality, the point-blank approaches the muzzle. If the line of sight be parallel to the axis of the bore, there will be no point-blank, as the trajectory will be constantly below the line of sight.

7. *What influence has the charge on the point-blank range?*

An increase of the charge determines a more distant point blank; its diminution produces a contrary effect.

8. *How do the diameter and weight of the projectile affect the range?*

As the ball increases in size and density, it will overcome with more ease the resistance of the air.

9. *Does the inclination of the line of sight to the horizon have much effect on the point-blank?*

Only when this inclination is very considerable. For any inclination between 0° and 15°, above or below the horizon, the difference may be wholly neglected.

10. *What is the effect on the point-blank range of firing upwards under a large angle?*

The action of the weight being nearly directly opposed to the impulsive force, the trajectory becomes compressed and the point-blank distance diminishes. The contrary effect obtains in firing downwards under a similar angle as the weight and the impulsive force then act in nearly the same direction.

11. *What is the extreme range of a piece of artillery?*

The distance from the muzzle to where the projectile finally rests.

12. *For a given velocity what effect has an increase of the angle of fire on the range?*

It increases with the angle of fire up to a certain limit, beyond which it diminishes.

13. *What angle gives the greatest range in* VACUO?

Forty-five degrees.

14. *When will this angle give the maximum range in practice?*

Only for feeble charges, and very heavy projectiles.

15. *How is the angle of greatest range in practice affected by a change in the velocity and size of the projectile?*

It seems to diminish as the velocity is increased, and as the ball is reduced. It is nearly 42° for mortars.

16. *Under what angle is a mortar usually fired?*

Under an angle of 45°, and the charge is varied according to the range required.

NOTE.—When mortars are employed in firing on inclined planes, up or down hill, should the inclination be considerable, the angle of greatest range, instead of being 45°, is 45° + ½ the angle which the plane makes with the horizon. Thus to strike an object elevated 15° above the plane on which the mortar rests, the angle of greatest range would be 45° + 7½°=52½° ; if the object was depressed 15°, the angle would be 45°—7½°=37½°.

17. *What are the advantages of this practice?*

Economy of ammunition; the recoil being inconsiderable, the mortar and its bed receive but little strain; the ranges are more uniform, and the effect of a slight error in the angle of fire is less than with any other.

18. *Is the mortar ever fired at any other angle than* 45°?

Yes; sometimes at 60°.

NOTE.—In this case the range is about *one-tenth* less than that due to an angle of 45°.

19. *When is a mortar fired under an angle of* 60°?

When the battery is situated very near the object assailed, and it is desired that the shells may fall upon the magazines of the besieged. It is evident that the higher projectiles are thrown, the greater the velocity they acquire in falling; besides they strike the object more directly and with increased violence.

20. *Under what angle were stone-mortars usually fired?*

Under an angle of 60°. and sometimes of 75°; that, in falling from a great height, the stone might have the maximum force of percussion.

21. *Under what angle should grenades be thrown from mortars?*

About 33°; otherwise they will be buried in the earth, and their fragments will not be sufficiently destructive.

22. *When a gun or howitzer is aimed with the line of metal horizontal, what is the elevation equal to?*

The natural angle of sight or dispart.

23. *How is the time of flight for siege mortars at an elevation of 45° determined?*

It is nearly equal to the square root of the range in feet divided by four.

NOTE.—The quotient gives the approximate time in *seconds*.

RANGES OF FIELD PIECES.

Kind of Piece.	Powder.	Projectile.	Elevation.	Range.	Time.	Remarks.
	Lb.		° ′	Yds.	Secs.	
3-in. rifle.........	1	Dyer shell, 9 lbs.	0.30	258	0.66	The ranges of other varieties of the 3-in. projectile do not vary greatly from those here given, which were calculated from Didion's formulæ by Gen. H[illegible]sk[illegible]r.
			1.0	489	1.29	
			1.30	700	1.91	
			2.0	892	2.53	
			2.30	1070	3.12	
			3.0	1234	3.70	
			3.30	1386	4.25	
			4.	1530	4.80	
			5.	1794	5.87	
			6.	2031	6.90	
			7.	2244	7.87	
			8.	2441	8.83	
			9.	2621	9.75	
			10.	2788	10.67	
			12.	3114	12.45	
			20.	3972	17.88	

RANGES OF FIELD PIECES.—*Continued.*

Kind of Piece.	Powder.	Projectile.	Elevation.	Range.	Remarks.
	Lbs.		° ′	Yds.	
12-pdr. smooth bore	2.5	Shot 12.3 lbs. I.V. =1486	0.15	181	These ranges were calculated by Gen. Haskin, from Didion's formulæ.
			0.30	320	
			0.45	452	
			1.0	562	
			1.15	662	
			1.30	750	
			1.45	832	
			2.0	906	
			2.30	1040	
			3.0	1158	
			3.30	1261	
			4.0	1355	
			5.0	1521	
			6.0	1663	
			7.0	1788	
			8.0	1899	
			10.0	2000	

RANGES OF FIELD PIECES.—*Continued.*

Kind of Piece.	Powder.	Projectile.	Elevation.	Range.	Time.	Remarks.
	Lbs.		° ′	Yds.	Secs.	
12-pdr. smooth bore	2.5	Case, 11.25 lbs. I.V.= 1495	0.30	324	0.77	These ranges were calculated from Didion's formulæ by General Haskin.
			1.0	554	1.45	
			1.30	733	2.09	
			2.0	882	2.65	
			2.30	1010	2.25	
			3.0	1120	3.80	
			3.30	1218	4.30	
			4.	1307	4.81	
			5.	1462	5.73	
			6.	1595	6.62	
			7.	1711	7.46	
			8.	1815	8.27	
			9.	1907	9.05	
			10.	1992	9.82	
	2.5	Shell, 9 lbs. I.V. =1680	0.30	367	0.82	
			1.0	590	1.52	
			1.30	765	2.18	
			2.0	900	2.78	
			2.30	1014	3.36	
			3.0	1112	3.88	
			3.30	1197	4.36	
			4.	1274	4.84	
			5.	1408	5.75	
			6.	1521	6.57	
			7.	1619	7.42	
			8.	1706	8.19	
			9.	1784	8.92	
			10.	1885	9.64	
			11.	1919	10.34	
			12.	1979	11.98	

RANGES OF THE MOUNTAIN HOWITZER.

Kind of Piece.	Powder.	Projectile.	Elevation.	Range.	Time.
			° ′	yds.	
Mountain Howitzer............	0.5	Shell, 9.35 lbs. strapped and charged.	0.	170	
			1.	300	
			2.	392	
			2.30	500	2 seconds.
			3.	637	
			4.	785	3 seconds.
			5.	1005	
	0.5	Sph. case 12.2 lbs.	0.	150	
			2.30	450	2 seconds.
			3.	500	
			4.	700	$2\frac{3}{4}$ seconds.
			4.30	800	3 seconds.

RANGES OF THE GATLING GUN.

[See Artillery School Circular No. 3, of 1874, and new Light Artillery Tactics.]

Kind of Piece.	Projectile.	Powder.		Time of firing.	Eleva-tion.	Range.	No. of fire.	No. of hits.	Size of target.
		Mortar.	Musket.						
			grs.	m.s.	° ′	yds.			
Half-inch.	Solid shot 450 grs.	....	70	......	0.51	100	......	......	24 × 6 ft.
		....	70	......	0.54½	200	......	....	"
		....	70	......	1.05	300	......	......	"
		....	70	......	1.26	500	......	......	"
		....	70	......	1.52	700	......	......	"
		....	70	.....	2.25	900	......	......	"
One-inch.	Canister 15 bullets .18 in. diam Wt. 9½oz.	¾ oz.	....	0.22	0.30	100	29	291	48 × 6 ft.
		"	....	1.30	0.50	150	101	691	"
		"	....	1.30	0.55	200	74	322	"
	Solid shot 8 oz.	¾ oz.	....	1.23	2.35	800	110	49	24 × 6 ft.
		"	....	1.0	3.20	1000	92	50	12 × 12ft.
		....	....	1.0	4.30	1200	87	22	"

Cartridges for the Gatling gun are made of sheet copper. The canister consists of a case terminated at one extremity by a hemispheroid of lead, called the head, which contains 15 bullets. The charge for the 1-in. gun, besides the powder, contains 6 grains of fulminate, and for the ½-in. ½ grain of fulminate. The solid shot consists of a case containing the above composition and charge of powder, and an elongated bullet weighing 8 ounces for the 1-in. and 450 grains for the ½-in. gun. Canister is not used with the ½-in. gun.

RANGES OF HEAVY ARTILLERY.

Kind of Piece.	Powder.	Projectile.	Elevation.	Range.	Time.	Remarks.
	lbs.	lbs.	° ′	yds.	secs.	
4.5 Rifle Gun.	3.25	Dyer shell, weight 25.5 c.=10491.4 I.V.=1303 feet.	0.30	290	0.69	These ranges were calculated from Didion's formulæ, by General Haskin.
			1.0	553	1.37	
			1.30	799	2.05	
			2.0	1017	2.69	
			2.30	2224	3.32	
			3.0	1414	3.94	
			3.30	1593	4.54	
			4.	1762	5.14	
			5.	2071	6.3	
			6.	2354	7.42	
			7.	2610	8.51	
			8.	2844	9.57	
			9.	3061	10.6	
			10.	3265	11.59	
	3.25	Solid Shot wt. = 32.5, diam. = 4″.45, c. = 13327.2, I. V. = 1280 feet.	1.0	540	....	These ranges were calculated from Didion's formulæ, by the compiler of this Hand Book.
			1.30	792	....	
			2.0	1000	....	
			2.30	1240	....	
			3.0	1445	....	
			3.30	1639	....	
			4.0	1823	....	
			5.	2170	....	
			6.	2485	....	
			7.	2780	....	
			8.	3056	....	
			9.	3313	....	
			10.	3556	....	
10-in. Rifle...	....	....	....	....	....	No ranges determined.
12-in. Rifle....	....	....	....	....	....	

RANGES OF HEAVY ARTILLERY.—*Continued.*

Kind of Piece.	Powder.	Projectile.	Elevation.	Range	Time.	Remarks.
	lbs.	lbs.	° ′	yds.	secs.	These ranges were calculated by General Haskin, from Didion's Formulæ.
10-in. Rodman	15	Shot, wt. 123.5, c. = 7028, I.V.=1275ft.	0.30	272	....	
			1.0	511	....	
			1.30	724	....	
			2.0	916	....	
			2.30	1090	....	
			3.0	1251	....	
			3.30	1401	....	
			4.	1539	....	
			5.	1793	....	
			6.	2019	....	
			7.	2225	....	
			8.	2414	....	
			9.	2587	....	
			10.	2749	....	
			15.	3429	....	
			20.	3976	....	
	10	Shell, wt. 101.75, c. = 5786, I.V.=1284 ft.	0.30	265	0.68	
			1.0	504	1.33	
			1.30	708	1.95	
			2.0	886	2.56	
			2.30	1048	3.15	
			3.0	1195	3.71	
			3.30	1330	4.25	
			4.	1455	4.79	
			5.	1680	5.83	
			6.	1879	6.82	
			7.	2057	7.78	
			8.	2217	8.71	
			9.	2363	9.6	
			10.	2498	10.46	
			11.	2621	11.31	
			12.	2737	12.10	

RANGES OF HEAVY ARTILLERY.—*Continued.*

Kind of Piece.	Powder, Mammoth.	Projectile.	Elevation.	Range.	Time.	Remarks.
	lbs.		° ′	yds.	secs.	
15-in. Rodman	50	Shot,	1.	398		These ranges were calculated from Didion's Formulæ by the compiler of this Hand Book.
		diam.=14″87	2.	755		
		wt. = 450 lbs.	3.	1076		
		I. V. = 1084,	4.	1370		
		c. = 11287·2.	5.	1629		
			6.	1884		
			7.	2126		
			8.	2347		
			9.	2556		
			10.	2755		
			15.	3622		
			20.	4351		
	50	Shell,	1.	470	1.25	
		diam.=14″87	2.	867	2.46	
		wt. = 344 lbs.	3.	1204	3.63	
		I. V. = 1200,	4.	1503	4.60	
		c. = 8628.4.	5.	1773	5.80	
			6.	2015	6.83	
			7.	2236	7.90	
			8.	2445	8.90	
			9.	2638	9.87	
			10.	2819	10.71	
			15.	3589	14.68	
			20.	3246	19.85	

RANGES OF HEAVY ARTILLERY.—*Continued.*

[See Artillery School Circular No. 2, of 1874.]

Kind of Piece.	Powder, Mammoth.	Projectile.	Elevation.	Range.	Time.	Remarks.
	lbs.		° ′	yds.	secs.	
15-in. Rodman	100	Shot, diam. 14″. 87 wt. 450 lbs., I. V. = 1534.	1.	769		Greatest range obtained 8220 yards.
			2.	1332		
			3.	1819		
			4.	2235		
			5.	2601		
			6.	2926		
			7.	3221		
			8.	3491		
			9.	3735		
			10.	3959		
			15.	4890		
			20.	5579		
			32.	7732		
	60	Shell, wt. = 344 lbs. I. V. = 1382.	1.	600	1.44	Shells filled with 12 lbs. of Musket powder.
			2.	1073	2.79	
			3.	1467	4.10	
			4.	1800	5.28	
			5.	2094	6.44	
			6.	2355	7.58	
			7.	2590	8.67	
			8.	2804	9.68	
			9.	3000	10.69	
			10.	3171	11.63	
			15.	3916	16.30	
			20.	4458	20.52	

RANGES OF HEAVY ARTILLERY.—*Continued.*

Kind of Piece.	Powder.	Projectile.	Elevation.	Range.	Time.	Remarks.
	lbs.		° ′	yds.	secs.	
15-in. Rodman	40	Shell, wt. = 315 lbs. I. V. = 949.	0.	293		Practical ranges [as determined at Fort Monroe Arsenal.]
			1.	484		
			2.	812		
			3.	1135		
			4.	1310		
			5.	1497		
			6.	1759		
			7.	1947		
			8.	2155		
			9.	2236		
			10.	2524		
			12.	2831		
			15.	3078		
			20.	3926		
			25.	4528		
			28.	4831		
			30.	4961		
8-in. siege howitzer, on 24-pdr. siege carriage.	4	Shell 45 lbs.	0.	251	0.66	
			1.	435	1.33	
			2.	618	2.	
			3.	720	3.	
			4.	992	4.	
			5.	1241	5.	
			12.30	2280	....	
24-pdr. iron howitzer on a Flank Casemate Carriage.	2	Shell 17 lbs.	0.	295		
			1.	516		
			5.	1322		
	1.75	Sph. Case.	2.	600	2.	
			5.30	1050	4.	
	2		3.30	880	3.	

RANGES OF HEAVY ARTILLERY.—*Continued.*

Kind of Piece.	Powder.	Projectile.	Elevation.	Range.	Time.	Remarks.
	lbs. oz.		° ′	yds.	secs.	
8-in. Siege mortar on iron bed.	0.8	Shell, 46 lbs.	45.	360	8.	From Benton's "Ord. & Gunnery.
	0.12		45.	703	12.5	
	1.0		45.	1082	15.	
	1.4		45.	1412	17.	
	1.8		45.	1741	18.5	
	1.12		45.	1985	20.	
	2.0		45.	2225	21.	
	0.8		45.	433	9.65	Ranges determined from experimental firing at Artillery School
	0.12		45.	727	12.50	
	1.0		45.	1029	15.0	
	2.4		45.	1275	16.80	
	0.8	Shell, 52 lbs.	45.	399	9.50	
	0.12		45.	717	12.45	
	1.0		45.	955	14.85	
	2.4		45.	1265	16.50	
8-in. Siege Howitzer as a Mortar.	0.4	Shell, 46 lbs.	45.	314		From Benton's "Ord. and Gunnery."
	0.8		45.	620		
	0.12		45.	1082		
	1.0		45.	1440		
	1.4		45.	1925		
10-in. Siege Mortar.	0.8	Shell, 90 lbs.	45.	189	6.4	
	1.0		45.	245	10.4	
	1.8		45.	854	14.2	
	2.0		45.	1122	17.2	
	2.8		45.	1410	18.4	
	3.0		45.	1676	19.8	
	3.5		45.	1848	20.9	
	4.0		45.	2064	21.9	

RANGES OF HEAVY ARTILLERY.—*Continued.*

[See Artillery School Circular No. 1, of 1874.]

Kind of Piece.	Powder.	Projectile.	Elevation.	Range.	Time.	Remarks.
	lbs. oz.		° ′	yds.	secs.	
10-in. Siege Mortar.	0.8	Shell, 92 lbs.	45.	193	6.33	Ranges determined from experimental firing at Artillery School.
	1.0		45.	550	10.75	
	1.8		45.	922	13.9	
	2.0		45.	1268	16.7	
	2.8		45.	1613	18.0	
	3.0		45.	1846	....	
	0.8	Shell, 102 lbs.	45.	217	6.92	
	1.0		45.	582	10.88	
	1.8		45.	1056	15.0	
	2.0		45.	1366	17.20	
	2.8		45.	1740	19.20	
	3.0		45.	1943	20.33	
	3.8		45.	2188	22.0	
	4.0		45.	2235	24.0	
	1.0		60.	545	15.0	
	1.4		60.	789	16.0	
	1.8		60.	939	19.0	
	1.12		60.	1072	20.0	
	2.0		60.	1189	20.4	
	2.4		60.	1337	21.6	
	2.8		60.	1459	23.5	
	2.12		60.	1582	24.4	
	3.0		60.	1667	25.4	
	3.4		60.	1732	26.5	
	3.8		60.	1870	27.2	
	3.12		60.	1935	28.0	
	4.0		60.	2085	29.0	

RANGES OF HEAVY ARTILLERY.—*Continued.*

[See Artillery School Circular No. 1, of 1874.]

Kind of Piece.	Powder.	Projectile.	Elevation.	Range.	Time.	Remarks.
	lbs. oz.		° '	yds.	secs.	
10-in. Sea-coast Mortar on iron bed with excentric axle.	5.0	10-in. Siege Mortar shell, filled with sand, weighing 96½ lbs.	45.	2720	25.2	Experimental firing at the Fort Monroe Arsenal, the mean of three shots at each range being taken.
	5.8		45.	2983	26.33	
	6.0		45.	3005	26.50	
	6.8		45.	3254	26.75	
	7.0		45.	3325	27.5	
	7.8	Columbiad shell filled with sand, weighing 104 pounds.	45.	3471	27.10	
	8.0		45.	3638	29.6	
	8.8		45.	3648	29.75	
	9.0		45.	3677	30.75	
	9.8		45.	4096	30.40	
	10.0		45.	4301	31.25	
	10.8		45.	4345	32.0	
	11.0		45.	4458	33.50	
	11.8		45.	4465	34.0	
	12.0		45.	4536	....	
24-pdr. Coehorn Mortar.	oz.	17-lb. shell.				
	0.5		45.	25		
	1.0		45.	68		
	1.5		45.	104		
	1.75		45.	143		
	2.0		45.	165		
	2.75		45.	260		
	4.0		45.	422		
	6.0		45.	900		
	8.0		45.	1200		

RANGES WITH SEA-COAST 13-INCH MORTARS, 20° ELEVATION.

Charge.	Mean time of flight.	Least range.	Greatest range.	Mean range.
lbs.	seconds.	yards.	yards.	yards.
4	8.	840	877	869
6	9.5	1209	1317	1263
8	11.66	1653	1840	1744
10	12.50	2010	2128	2066
12	14.25	2369	2688	2528
14	15.25	2664	2780	2722

RANGES WITH 13-INCH MORTARS, AT 45° ELEVATION.

Kind of Piece.	Powder.	Shell.	Elevation.	Range.
	Lbs.	Lbs.		Yards.
13-in. Mortar.	20	200	45°	4325

RANGES WITH 13-INCH MORTARS, AT 45° ELEVATION.

Charge.		Flight.	Fuze.		Range.
lbs.	oz.	seconds.	inches.	10ths.	yards.
7		21.4	4	2⅔	2190
7	8	22.4	4	4	2346
8		23.2	4	6	2480
8	8	23.8	4	7½	2600
9		24.4	4	8¾	2734
9	8	24.9	4	9¾	2853
10		25.4	5	1	2958
10	8	25.9	5	1¾	3026
11		26.3	5	2½	3150
11	8	26.7	5	3½	3246
12		27.0	5	4	3327
12	8	27.4	5	4¾	3404
13		27.7	5	5½	3470
13	8	28.0	5	6	3552
14		28.3	5	6½	3617
14	8	28.5	5	7	3681
15		29.0	5	8	3739
15	8	29.1	5	8¼	3797
16		29.2	5	8½	3849
16	8	29.4	5	8¾	3901
17		29.6	5	9	3949
17	8	29 8	5	9½	3997
18		29.8	5	9¾	4040
18	8	30.0	6	0	4085
19		30.2	6	0¼	4123
19	8	30.3	6	0½	4160
20		30.5	6	1	4200

RANGES WITH SEA-COAST 13-INCH MORTARS.

From experiments at Fort Monroe Arsenal, [see Artillery School Circular No. 1, of 1874,] the mean of three shots being taken.

Mortar powder.	Elevation.	Range.	Time of flight.
lbs.	degrees.	yards.	seconds.
10	30	2875	19.
10	45	3187	25.8
15	45	3759	28.
20	45	4636	31.75
10	60	2852	32.75
15	60	3375	36.75
20	60	3893	39.16

NOTE.—Fire-balls, according to their size, are fired from mortars of corresponding calibre. With a charge of ONE TWENTY-FIFTH its weight, the ball is thrown 600 to 700 yards.

PART V.

RICOCHET.

1. *What is understood by* RICOCHET FIRING?

That obtained by firing a piece at very small angles of elevation, by which means the projectile which falls on ground of ordinary firmness at an angle not greater than 20°, or upon water at 4° or 5°, will make one or more bounds. In this case the projectile is said to *ricochet.*

NOTE.—*Rolling-fire* is a particular case of ricochet fire, the axis of the piece being parallel, or nearly so, with the ground. The piece is first directed at the object and then the natural line of sight depressed so as to strike the ground about 80 yards in front of the muzzle; with the pendulum hausse, aim directly at the object with the slider fixed at the *zero* of the scale.

2. *What is the object of ricochet firing?*

To enfilade a face of the enemy's work, which is effected by causing a projectile to bound along the terre-plein of the face with the view of annoying his cannoneers, and dismounting his pieces. It is employed also in harassing an enemy, when formed or in the act of forming behind a rising ground or other obstacle, taking post in a wood, etc.; and in enfilading a line of troops.

3. *What are the peculiar advantages of this fire?*

In being able to reach objects which cannot be reached by direct fire, on account of intervening obstacles.

4. *In enfilading the face of an enemy's work, what is the object to be fired at?*

Usually some point of the interior crest of the parapet which covers a flank of the terreplein to be reached.

5. *What is the* POINT OF FALL?

The point of the terreplein which is first struck by the projectile, after having grazed the interior crest.

6. *What is the* ANGLE OF FALL?

It is the angle made at the point of fall by the tangent to the trajectory with a horizontal line in the plane of fire.

7. *How does the angle of fall compare with that of* ELEVATION?

It is greater.

8. *Upon what do the charge and elevation depend?*

Upon the distance of the object from the battery; upon the difference of level between these points; the distance of the desired point of fall from the parapet; the height of the parapet, etc.

9. *If the embrasure be such that the object is masked, how is the piece pointed?*

The *direction* must be given, as with the mortar, by the plummet; this is held by the person who points, in such a manner as to cover both the line of metal and the object. The *elevation* is then given by the quadrant.

10. *What is the maximum angle of elevation in ricochet firing?*

Against troops it should seldom exceed 3° above the surface of the ground occupied by them. Against fortresses, forts and fortified lines, it varies from 3° to 9° above the horizontal.

11. *At what distance from the object should the ricochet battery be placed?*

Never at a greater distance than 600 yards.

12. *In enfilading a work, how should the ricochet firing be conducted?*

The projectile should be made to graze the parapet, while in the descending branch of the trajectory; and this must be effected by regulating the charges and elevating or depressing the piece until the shot is seen to fall just over the interior crest of the parapet. Light charges are generally used, varying from *two-thirds* to *one-eighth* of the ordinary charge.

13. *What pieces are best adapted for ricochet fire?*

Smooth bore pieces which throw heavy shells; for, if used to enfilade a work, the shells lodge and explode in the traverses, and render the guns more liable to be dismounted and their detachments put *hors de combat.*

NOTE.—The 8-in. howitzer and the 8 and 10-in. mortars are employed in ricochet fire in siege operations; the first two when the angle of fall is less than 10°, and the last when it is less than 15°, the proper elevation being given to the mortar by raising the rear of the bed. The direction of the ricochet in case of rifle projectiles is uncertain.

14. *What determines the* NATURE *of the ricochet?*

The angle of fall: it is *flattened* when this angle does not exceed 4°, and *curvated* when it is between 6° and 10°. In the first of these fires, the velocities are great, and in the second small.

15. What *are the charges for a* FLATTENED RICOCHET *for siege howitzers at an angle of about* 3°?

Distances.	Elevation.	Charge.
550 yards.	1° 45′	3 lbs.
440 "	2° 14′	2 lbs. 3 oz.
330 "	2° 15′	1 lb. 12 oz.
220 "	2° 45′	1 lb. 2 oz.

16. *What are the charges for a* CURVATED RICOCHET *for a siege howitzer at an angle of about* 10° ?

Distance.	Elevation.	Charge.	Remarks.
550 yards.	7° 30′	1 lb. 4 oz.	The height of the object above the level of the battery being supposed to be 20 feet.
440 "	"	1 lb. 1 oz.	
330 "	"	14 oz.	
220 "	"	10 oz.	

PART VI.

RECOIL.

1. *What is meant by the* RECOIL *of a piece of artillery?*

The retrograde motion impressed upon cannon by the discharge is termed the *recoil*.

2. *What causes the recoil of a piece?*

The gas produced by the ignition of the charge in the bore, expanding with equal force in every direction, finds only two ways of escape (the muzzle and vent); the pressure upon these points will therefore cease while it will be proportionally increased upon the parts directly opposite, that is, the bottom of the bore and that portion directly opposite the vent, producing in the first case the recoil, and in the other, indirectly, the dipping of the muzzle.

3. *How far does a gun usually recoil?*

This depends entirely upon the nature and inclination of the ground upon which the carriage stands, the situation of the trunnions, angle of elevation, comparative weight of the gun and carriage, and upon the strength of the charge.

4. *What proportion does the velocity of the recoil of a piece bear to that of a projectile?*

Inversely as their weights, or masses.

5. *What proportion exists between the pressure acting upon the part of the bore of a piece directly opposite the vent, and that which occasions the recoil?*

As the square of the diameter of the vent is to the square of that of the shot.

6. *Has the recoil any effect upon the flight of a projectile?*

No appreciable effect, the projectile being expelled from the gun before it has recoiled a fraction of an inch.

7. *What are the principal inconveniences arising from the recoil of guns?*

The necessity of running up the gun after every discharge, and consequent fatigue to the men and loss of time; it also necessitates that a greater breadth should be given to the terreplein of a work.

8. *What causes the muzzle of a piece of artillery to dip when fired.*

The sudden pressure of gas acting upon the part of the bore directly opposite the vent, causes the piece to strike downwards upon the elevating screw or quoin, and the reaction to make the muzzle dip.

9. *What influence has the position of the axis of the trunnions in respect to that of the bore upon the recoil?*

If the axis of the trunnions be below that of the piece, the pressure of the breech upon the carriage will increase as the distance between the axes increases; and from this pressure there will arise a friction upon the ground which will diminish the recoil. On the contrary, if the axis of the trunnions be above that of the piece, the breech will have an upward tendency, the recoil will be increased, but the carriage, and particularly the axletree, will be subjected to less strain. Hence, the recoil will be transmitted directly to the trunnions, if their axis (as in our service) be situated in the same plane with the axis of the piece. The size of the trunnions is made proportional to the force of the recoil.

10. *Does the position of the trunnions with reference to the centre of gravity of the piece influence the recoil?*

Yes; if in field and siege cannon fired horizontally, or under very small angles, the portion in rear of the trunnions is heavier than that in front, the pressure of the trail on the ground is increased so as to diminish the recoil.

PART VII.

WINDAGE.

1. *What is meant by* WINDAGE.

Windage is the space left between the bore of a piece and its projectile, and is *measured by* the difference of their diameters, and the *true* windage is measured by the difference between the *true* diameters of the bore and the projectile.

NOTE.—The *true* windage increases slightly with the calibre, and is greater for solid shot, which are sometimes fired hot, than for hollow projectiles which are unheated.

2. *Is it absolutely necessary to allow windage?*

Yes, in order to make an allowance for a piece becoming foul, the expansion of projectiles by heat, the incrustation of rust, and for the tin straps of fixed ammunition.

Windage facilitates loading and diminishes the danger of bursting the piece ; it is rendered necessary by the mechanical impossibility of making every projectile of the exact size and shape to fit the bore.

3. *What advantages are derived from reducing the windage?*

An increase in the accuracy of fire ; a more extensive range, or an equal range with a smaller charge, as there

is less loss of gas ; and less injury to the surface of the bore.

4. *Why should the bore suffer less injury by a diminution of the windage?*

Because in proportion to the decrease of windage there will be less space for the reflections of the projectile along the bore, and consequently less injurious power exercised upon it.

5. *What is the loss of velocity by a given windage proportional to?*

It is directly as the windage, and inversely as the diameter of the bore very nearly.

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6. *What was the loss of velocity, in the pieces of the old system, by the windage of the ball?*

Kind of Gun.	Charge of powder.	Initial velocity of ball.		Loss of velocity by Windage of 1-40th diam.	
		Without windage.	With windage of 1-40th diam.		
	lbs.	feet.	feet.	feet.	per cent.
32-pdr. Sea-Coast......	4	1444	1271	173	12
24-pdr. Siege......	4 6	1600 1890	1433 1723	167 167	10 9
12-pdr. 25 calibres.......	2 3 4	1617 1915 2124	1444 1742 1951	173 173 173	11 9 8
12-pdr. Field, 16 calibres....	2 3 4	1528 1793 1992	1370 1634 1834	158 158 158	10 9 8
6-pdrs. Field.....	1.5	1734	1560	174	10

7. *What windage is allowed to guns and howitzers?*

Sea Coast.							Siege.		Field.			
20-in.	15-in.	13-in.	10-in.	12-in. rifle.	10-in. rifle.	24-in. howitzer.	4½-in. rifle.	8-in. howitzer.	3½-in. rifle.	3-in. rifle.	12-pdr.	12-pdr. mount'in howitzer.
in. .13	in. .13	in. .13	in. .13	in. .08	in. .08	in. .14	in. .05	in. .12	in. .05	in. .05	in. .10	in. .10

8. *What windage is allowed to mortars?*

SEA COAST.			SIEGE.		
15-in.	13-in.	10-in.	10-in.	8-in.	24-pdr. Coehorn.
in.	in. .13	in. .13	in. .13	in. .12	in. .14

PART VIII.

GUNPOWDER.

1. *What are the ingredients in* GUNPOWDER?

Saltpetre, charcoal, and sulphur.

2. *What are the proportions?*

In the United States, 75 to 76 saltpetre, 14 to 15 charcoal, and 10 sulphur.

England,	75	Saltpetre,	15	Charcoal,	10	Sulphur.
France,	75	"	12½	"	12½	"
Prussia,	75	"	13½	"	11½	"

3. *What is the combustible ingredient?*

Charcoal.

NOTE.—This ingredient affects most the quality of gunpowder. It should be light, friable and porous, and made from willow and black alder, black dogwood and poplar.

4. *What is the use of the saltpetre?*

It furnishes the oxygen necessary to support a rapid combustion, and to change the whole mass into gas.

NOTE.—All of the saltpetre used in the United States for the manufacture of gunpowder is brought from India in a crystallized state, called crude saltpetre.

5. *What is the use of sulphur?*

It adds consistency to the mixture and intensity to the

flame, besides rendering the powder less liable to absorb moisture.

NOTE.—Sulphur is brought to this country principally from Sicily in the crude state.

6. *On what does the quality of gunpowder depend?*

On the intimate mixture and proper proportions and. purity of the ingredients.

7. *In what does the manufacture of gunpowder consist?*

In pulverizing the ingredients, incorporation, compression, granulation, glazing, drying, and dusting.

8. *Explain the mode of performing these different operations.*

Pulverizing. The saltpetre is usually pulverized sufficiently when it comes from the refinery. The charcoal is placed in large cast-iron barrels with twice its weight of bronze balls. The barrel has several ledges on the interior, and is made to revolve from 20 to 25 times in a minute. It is pulverized in two or three hours. The sulphur is placed in barrels made of thick leather stretched over a wooden frame, with twice its weight of bronze balls from 3 to 5 in. in diameter, and the barrel made to revolve about 20 times per minute.

The sulphur is pulverized in four to eight hours.

Incorporating. The ingredients having been weighed out in the proper proportions, the charcoal and sulphur are put together in a rol ing barrel similar to that in which the sulphur is pulverized, and rolled for one hour. The saltpetre is then added, and rolled for three hours longer. In some mills this operation is omitted. It is now taken to the cylinder, or *rolling mill.* This consists of two cast-iron cylinders rolling round a horizontal axis in a circular trough of about 9 feet in diameter, with a cast-iron bottom. The cylinders are 6 feet in diameter, 18 inches thick on the face,

and weigh about 8 tons each. They are followed by a wooden scraper, which keeps the composition in the centre of the trough.

A charge of 75 lbs. in some mills, and 150 lbs. in others, is then spread in the trough of the rolling-mill, and moistened with 2 to 3 per cent. of water, according to the hygrometric state of the atmosphere.

It is rolled slowly at first, and afterwards from 8 to 10 revolutions of the roller per minute, for 1 hour for 50 lbs. and 3 hours for 150 lbs. of composition. A little water is added, as the process advances, if the composition becomes very dry, which is judged of by its color.

When the materials are thoroughly incorporated, the cake is of a uniform, lively, brownish red color. In this state it is called *mill-cake*.

The quality of the powder depends much on the thorough incorporation of the materials, and burns more rapidly as this operation is more thoroughly performed.

The mill cake is next taken to the press-house, to be pressed into a hard cake.

Pressing. The mill-cake is sprinkled with about 3 per cent. of water, and arranged in a series of layers about 2 inches thick, separated by brass plates. A powerful pressure is brought to bear on the layers, which are subjected to the maximum pressure for about 10 to 15 minutes, when it is removed. Each layer is thus formed into a hard cake about an inch thick.

Granulating. The cake is broken into pieces by means of bronze toothed rollers revolving in opposite directions, their axes being parallel and the distance between them regulated as required. *Fluted* rollers are sometimes used. The pieces are passed through a succession of rollers, each series being closer together, by which the pieces are broken

into others still smaller, which pass over a sieve to another roller, the small grains passing through the sieve into a receiver below, until the whole is reduced to the required size. The various sized grains are separated by the sieves between the different rollers.

Glazing. Several hundred pounds of the grained powder, containing from 3 to 4 per cent. of water, are placed in the glazing-barrel which is made to revolve from 9 to 10 times per minute, and in some mills from 25 to 30 times per minute. Usually from 10 to 12 hours are required to give the necessary glazing. In this operation the sharp angles are broken off, thereby diminishing the dust produced in transportation, and the surface of the grain receives a bright polish.

Drying. The powder is spread out in sheets stretched upon frames in a room raised to a temperature of 140° to 160° by steam pipes or by a furnace. The temperature should be raised gradually, and should not exceed 160°, ventilation being kept up.

Dusting. The powder is finally sifted through fine sieves, to remove all dust and fine grains. The dust obtained in this and previous operations may be worked over to make other powders.

9. *What is understood by* IGNITION, INFLAMMATION, *and* COMBUSTION *as applied to gunpowder?*

By *ignition* is understood the setting on fire of a particular point of the charge; by *inflammation*, the spread of the ignition from one grain to another; by *combustion*, the burning of each grain from its surface to the centre.

10. *Does powder inflame instantaneously?*

No; its inflammation is gradual and progressive, and in a gun the projectile commences to move before the whole charge is ignited.

11. *Why should gunpowder be grained?*

In order to facilitate the transmission of the flame. When the powder is very fine, and in large and compact charges, the flame cannot penetrate it, and it burns slowly and in successive layers.

12. *Which burns quickest, the small or large grained powder?*

Before coming to the limit of dust, the smaller the grain, the more rapid the combustion, and the greater the bursting force of the powder.

NOTE.—The largest portion of a grain of gunpowder is burned in the first two-tenths of the time required to cousume the entire grain: and as a grain of ordinary cannon powder requires 0.1 second for its combustion, the largest portion of the grain will be burned in the first .02 second. If we consider the velocity of the projectile on leaving the gun and the time necessary to overcome its inertia in the first period of its movement, we shall see that a very large portion of each grain is burned up before the projectile begins to move. *If the size of the grain be increased, the weight of the charge remaining the same, the amount of gas evolved in the first instants of time will diminish and consequently the pressure on the breech will be less.* This idea has been carried out by the late General Rodman, by converting the powder into one or more cakes perforated with numerous small holes for the passage of the flame. In this way a large portion of the powder is consumed on an increasing instead of a decreasing surface, and the amount of gas given out in the last moments will be greater than in the first; and thus the strain on the breech of a gun may be very much diminished without proportionately diminishing the velocity communicated to the projectile.

13. *What are the qualities of good powder?*

It should be perfectly free from dust, uniform in strength and size of grains, angular and irregular in form; in color, brownish black, or slate; so hard as not to be easily crushed by pressure with the finger; and should

leave no bead or foulness when flashed in quantities of 10 grs. on a copper plate. It should give the required initial velocity to the projectile, and not more than the maximum pressure on the gun, and should absorb but little moisture from the air.

14. *Why should the grains be angular?*

Because they present a greater surface to the action of the flame. and therefore burn quicker.

15. *Why should powder be free from dust?*

Because the dust fills up the intervals between the grains, and forming a compact mass, retards combustion.

16. *How many kinds of powder are used in our land service?*

Five, distinguished as *Mammoth*, *Cannon*, *Mortar*, *Musket* and *Rifle* powder, all made in the same manner, of the same proportion of materials, and differing only in the size of the grain. Mammoth is employed for the heaviest sea-coast guns; cannon for smaller sea coast guns mortar for mortars and field and siege pieces; musket for rifle-muskets; and rifle for pistols.

17. *How is the size of the grain for each kind of powder tested?*

By standard sieves made of sheet brass pierced with round holes.

18. *How many grains of powder are in* 10 *grs. Troy Weight?*

Cannon, 150; *Musket*, 2,000 to 2,500; and *Rifle*, 12,000 to 15,000.

NOTE.—13 grs. of Du Pont's Mammoth Powder weigh 1000 grs. Troy Weight.

10 prisms of Du Pont's hexagonal Powder weigh 1000 grs. Troy Weight.

19. *What is the object in glazing powder?*

In the operation of glazing the sharp angles are broken off, thereby diminishing the dust produced by transportation, and the surface of the grain receives a bright polish, and hardened to protect it from the action of the moisture.

20. *What is the established mode of proving the strength of powder in the U. S.?*

At least 50 barrels of powder are thoroughly mixed together. One barrel of this is proved by firing three rounds from a musket in case of musket powder, with service charge of 70 grains of powder and a projectile weighing 405 grains. It should give an initial velocity of not less than 1240 feet. Powder is now tested in the particular gun or piece in which it is to be used. The piece is fired with the maximum charge, and the solid projectile suitable for it. It should not give too high a pressure, and should give a suitable initial velocity.

21. *How is the required initial velocity to be given to the ball determined?*

By the Ballistic Pendulum, the Gun Pendulum, the Electro-Ballistic Machines, the Schultz Chronoscope or the Le Boulengé Chronograph, the two last being now generally used in service.

22. *How is the strain upon the gun determined?*

By the pressure-piston of Capt. Rodman. (See Ord. Manual, p. 251.)

23. *What is understood by the* GRAVIMÈTRIC DENSITY *of powder?*

It is the weight of a given measured quantity. It is usually expressed by the weight of a cubic foot in ounces, and has a mean value of 855 ounces.

24. *What should be the* SPECIFIC GRAVITY *of gun powder?*

Not less than 1.75.

25. *What is the hygrometric proof of powder?*

Samples are placed in shallow tin pans, set in a tub, the bottom of which is covered with water; the pans should be about an inch above the water, and the tub covered. Good powder will not absorb more than $2\frac{1}{2}$ per cent. of moisture in 24 hours.

26. *How can the relative quickness of two kinds of powder be determined?*

By burning a train laid in a circular or other groove, which returns into itself, made in a piece of hard wood: one-half of the groove being filled with each kind of powder, and fire communicated at the junction of the two trains, the relative quickness is readily deduced from observation of the point at which the flames meet.

27. *What is the expansive velocity, and pressure of ignited powder?*

The expansive velocity is about 5,000 feet per second, and pressure about 2,000 atmospheres.

28. *What is the weight of a cubic inch of powder?*

About half an ounce; a cubic foot will therefore weigh about 54 pounds, and 32 cubic inches, one pound.

29. *How is government powder packed?*

In barrels of 100 lbs. each; the barrels being large enough to allow sufficient space for the powder to move when rolled to prevent its caking.

30. *How are the barrels marked?*

On both heads (in white oil-colors, the head painted black), with the number of the barrel, the *name* of the manufacturer, *year* of fabrication, and the *kind* of powder, —*mammoth*, *cannon*, *mortar*, or *musket*,—the mean initial velocity, and the pressure per square inch on the pressure piston. Each time the powder is proved, the initial velo-

city is marked below the former proofs, and the date of the trial opposite it.

31. *When powder is injured by dampness, can it be restored?*

If the water absorbed does not exceed 7 per cent., it can be by drying. If it has absorbed from 7 to 12 per cent., after drying it remains porous and friable, and is unfit for transportation. In this case it is better to work it over.

32. *How is powder stored?*

In magazines especially constructed for the purpose. The barrels are generally placed near the sides, three tiers high, or four tiers if necessary; small skids should be placed on the floor and between the several tiers of barrels in order to steady them, and chocks should be placed at intervals on the lower skid, to prevent the rolling of the barrels.

33. *How are the different kinds of powder arranged?*

Those barrels of the same kind, place, and date of fabrication, &c., are piled together.

34. *Should it be necessary to pile the barrels more than four tiers high, what is done?*

The upper tiers are supported by a frame resting on the floor, or the barrels may be placed on their heads with boards between the tiers.

35. *What is necessary for the preservation of the powder?*

The magazine should be opened and aired in clear, dry weather, when the temperature of the air outside is lower than that inside. It should not be opened in damp weather if it can be avoided. The ventilators must be kept free; no shrubbery or trees should be allowed to grow so near as to protect the building from the sun.

36. *How may the moisture of a magazine be absorbed?*

By chloride of calcium suspended in an open box under the arch, and renewed from time to time.

37. *When the magazine is open, what precautions should be observed?*

The sentinel or guard should have no fire-arms, and any one who enters it should take off his shoes, or put socks over them. No sword or cane, or any thing which might occasion sparks should be carried in.

38. *How should powder in barrels be transported?*

The barrels should never be rolled; they should be carried in hand-barrows or slings made of rope or leather. In wagons, the barrels should be packed in straw, and not allowed to rub against each other, and the whole covered with thick canvas. In transportation by railroad, each barrel should be carefully boxed and packed so as to avoid all friction. The barrels should have a thick tarpaulin under them, and the cars should have springs similar to those of passenger cars.

39. *What precaution should be used to prevent powder caking?*

The barrels should be taken outside the magazine and rolled on boards.

40. *Where should cartridge bags be filled?*

In the filling room of the laboratory, or a small magazine, and not in the general magazine.

PART IX.

PROJECTILES.

1. *How many classes of projectiles are made use of in the service?*

Two, rifle and smooth-bore projectiles.

2. *How are rifle projectiles designated?*

By the d ameter of the bore of the piece in which they are to be used in inches; their shape is oblong and *they are not a'tached to their cartridges.*

3. *How a e smooth-bore pr jectiles designated?*

Hollow shot, by the weight in pounds of the solid shot of the same diameter, or by the diameter of the bore of the piece in which they are to be used, in inches; *solid shot* are designated in the same manner.

4. *Name the project les used with smooth-bore pieces.*

Solid s ot; shells; spherical case, or shrapnel; canister; grape; grenades; carcasses; light and fire balls.

5. *N me tho e used with rifle guns?*

Solid shot; shells; case-shot, and canister.

6. *What is a solid shot?*

A solid body usually of cast-iron, almost exclusively appropriated to guns. The gun sometimes derives its denomination from the weight of the solid shot, but generally from the diameter of the bore in inches.

7. *What is a shell and its use?*

A hollow, cast iron projectile, made strong enough to penetrate earth works, wooden buildings, etc., without

breaking ; it is loaded with a bursting charge of rifle or musket powder which gives great force to the fragments. Fire is communicated to the charge by means of a fuze inserted in the hole by which the shell is loaded, and the time of explosion is regulated by the length of the fuze. When fired at troops, it should be prepared to burst over their heads, or, if the ground be favorable, to ricochet a little in front, and plunge into the column. When fired at works or buildings it should explode after penetration.

8. *Name the principal parts of a spherical shell.*

The *cavity*, the *fuze-hole*, and the *ears*. The *cavity* contains the bursting charge of powder and the incendiary composition. The *fuze-hole* is used in inserting the charge and to hold the fuze which communicates fire to it. The *ears* are two small indentations near the fuze hole of very large shells to insert the shell-hooks with a view of raising the shell to the bore of the piece.

9. *What is a case-shot, and what advantages does it possess?*

It is a hollow, cast-iron projectile much thinner than the ordinary shell, and filled with leaden bullets and a charge of powder sufficient to burst it, which is done by means of a fuze as with a common shell at any required distance. It is thus calculated to extend all the advantages of canister shot, to distances far beyond the reach of that projectile. It is fired both from guns and howitzers.

10. *What is a canister shot?*

It consists of a hollow tin cylinder filled with cast-iron or lead balls, which vary in size and number with the calibre and kind of piece ; the cylinder is closed at the bottom by a thick cast-iron plate, and at the top by one of sheet iron. The interstices between the balls are filled with dry saw-dust the object of which is to give more so-

lidity to the mass and prevent the balls from crowding on each other when the piece is fired.

A canister shot for the three-inch rifle contains from one hundred to one hundred and fifty leaden balls. A canister shot for a smooth-bore gun contains 27 small cast-iron balls arranged in four layers the top of 6 and the others of 7 each. A canister shot for a howitzer contains 48 small iron balls in 4 layers of 12 each.

Canister are fired at ranges not exceeding 400 yards, but their most destructive effects are from 100 to 200 yards.

11. *What are grape-shot?*

A certain number of iron balls, usually nine, put together by means of two cast-iron plates, two rings, and one pin and nut. Each plate has on the inside three beds for the shot, of a depth equal to half the thickness of the plate, and of the form of a spherical segment, the curvature of which is the same as that of the shot. An iron pin riveted to the bottom iron plate passes through the centre and also through the top plate, where the whole is secured by a nut and screw.

NOTE.—The use of these shot for field pieces has been discontinued, canister answering the purpose.

12. *How were the balls fixed in the old pattern?*

They were placed in tiers around an iron pin attached to an iron tompion at the bottom, and put into a canvas bag, and then quilted around with a strong cord.

13. *What is a grenade?*

A shell thrown from the hand, or in barrels from mortars of large calibre, and ignited as other shells by means of a fuze.

14. *How many kinds of grenades are made use of?*

Hand-grenades and *rampart-grenades;* old six-pounder spherical-case may be used for the former and shells of any calibre for the latter.

15. *To what purposes are grenades applied?*

They are useful in the defence of works, the smaller. thrown by hand into the head of a sap, trenches, covered way, or upon the besiegers mounting a breach ; the larger kinds are rolled over the parapet in a trough.

Hand grenades are intended to be used against the enemy when he has reached such parts of the defences (the bottom of the ditch for example), as are not covered by the guns, or the muskets of the infantry posted on the banquettes. After the enemy has passed the abattis and jumped into the ditch, hand-grenades will be used ; and then if he mounts the parapet, he must be met there with the bayonet.

Ketchum's hand-grenade is a small oblong percussion shell which explodes on striking the object.

16. *What is a carcass and its use?*

It is a spherical shell having three additional holes, of the same dimensions as the fuze hole, pierced at equal distances apart in the upper hemisphere of the shell, and filled with a composition which burns with intense power from eight to ten minutes, and the flame issuing from the holes sets fire to everything combustible within its reach ; it is used in bombardments, setting fire to shipping, etc. ; and is projected from cannon like a common shell.

17. *What is a substitute for a carcass?*

Common shells loaded in the following manner : The bursting charge is placed in the bottom of the shell in a flannel bag, over which carcass composition is driven until the shell is nearly filled ; then insert four or five strands of quick-match, which must be secured by driving more

composition upon it. These shells, after burning as a carcass, explode.

18. *What is a fire-ball, and its use?*

It is a projectile of an oval shape, formed of sacks of canvas filled with combustible composition which emits a bright flame. Its use is to light up the enemy's works, and it is loaded with a shell to prevent it from being approached.

19. *What is a light-ball?*

Light balls are the same as fire-balls, except that there is no shell in them, as they are used for lighting up our own works.

20. *What is a smoke-ball?*

It is a hollow sphere similar to a light-ball, and filled with a composition which emits a dense, nauseous smoke; it is employed to suffocate the enemy's miners when at work, or to conceal one's own operations; it burns from twenty-five to thirty minutes.

21. *Name the different kinds of rifle projectiles in our service.*

The *Hotchkiss*, the *Ordnance*, the *Absterdam* and the *Eureka*. Besides these there are many other varieties, and of each variety there are several modifications.

22. *Describe the Hotchkiss projectile.*

It consists of two pieces of cast-iron, the body, and the cup covering the base of the body; between these is placed a band or ring of lead, (the action of the charge being to crowd the cup against this band or ring, thereby expanding it), which is compressed by the discharge so as to take the grooves.

23. *Describe the Ordnance projectile.*

It consists of a cast-iron body, with a sabot composed an alloy of lead and tin, which is cast on the base of the

projectile, and is held in position by undercuts and dovetails, the action of the charge being to force the sabot on the cast-iron body and to make it take the grooves.

24. *Describe the Absterdam projectile.*

The best form is cast in a single piece, and has an expanding ring of brass which projects three-eighths of an inch beyond the base of the projectile.

25. *Describe the Eureka projectile.*

It consists of a cast-iron body in one piece, with a brass sabot; the sabot is an annular disk intended to move on the frustum of a cone with an expanding cup in rear to take the grooves.

26. *Name the projectiles used with field guns.*

Shell, case-shot, canister and solid shot.

27. *What is understood by a round of ammunition?*

It consists of a projectile and its cartridge. In case of the 12-pdr. gun and the mountain howitzer, the projectile and cartridge are attached to the same *block* of wood called a *sabot*, the whole being termed *a round of fixed ammunition.*

28. *What is understood by strapped ammunition?*

Where the projectile and cartridge bag are not united but carried separately, the projectile being attached to a sabot, and the cartridge bag to a block of wood called a *cartridge-block* resembling a sabot.

29. *What difference is there in sabots for field service?*

Sabots for solid shot and spherical case have *one groove* for attaching the cartridge, and for canister *two grooves.*

30. *How are projectiles for field pieces fastened to the sabot?*

By straps of sheet tin, or of *strong canvas,* when tin or sheet-iron cannot be procured.

31. *How many straps are employed, and how are they fastened?*

For *shot*, there are two straps crossing at right angles, one passing through a slit in the middle of the other. For *shells*, there are four straps soldered to a ring of tin, or fastened to it by cutting four slits in the ring, into which the upper ends of the strap are hooked, and turned down on the inside of the ring.

32. *What is a* CANISTER FOR 12-PDR. FIELD GUN?

It consists of a tin cylinder attached to a sabot and filled with cast-iron shot.

33. *How is it made?*

The cylinder is fastened to the sabot by six or eight nails, and a plate of rolled iron is placed at the bottom on the sabot. It is closed with a sheet-iron cover after being filled, the top of the cylinder being cut into strips ½ an inch long, and turned down over the cover.

34. *In case of heavy smooth bore guns are solid shot attached to a sabot?*

They are generally without a sabot.

35. *How is it with shells and spherical case?*

Except for the 8-inch siege howitzer, they are all strapped to sabots made of thick plank, with strips of tin, as in case of strapping shot for field service.

36. *How is it with canister for smooth bore sea-coast guns?*

They have no sabot; the tin is turned over the iron bottom.

37. *Are sabots used with grape shot?*

No.

38. *What is the object of fixing solid shot or shells to wooden bottoms?*

To prevent injury to brass cannon; and to insure the

fuze of a shell being retained in or near the axis of the piece.

39. *What proportion does the weight of one spherical solid shot bear to that of another?*

The proportion is, as the cubes of their diameters.

40. *How is the weight of a spherical cast-iron solid shot or shell determined?*

Multiply the cube of the diameter of the shot in inches, or the difference of the cubes of the exterior and interior diameters of the shell by 0.132566 for the weight in pounds. In case of lead balls, the multiplier is 0.214.

NOTE.—The cube of the radius, *in inches*, of a cast-iron spherical solid shot will be very nearly equal to its weight in pounds.

41. *How is the diameter of a cast-iron shot of a given weight found?*

Divide the weight in pounds by 0.132566, and extract the cube root of the quotient, which will be the diameter in inches.

42. *How is the quantity of powder which a spherical shell will contain found?*

Multiply the cube of the interior diameter of the shell in inches, by 0.01744 for the weight of powder in pounds.

NOTE.—These multipliers are found as follows: Suppose W to represent the weight of a body, D its density, V its volume, and g the weight of the unit of mass, then $W=DVg$. Now, if a cubic inch of distilled water at the standard temperature be taken as the unit of mass, g will be numerically $\frac{62.5}{1728}$ pounds. Hence, $W=VD\frac{62.5}{1728}=0.0361689DV=0.036201D\frac{\pi}{6}d^3$ (supposing d to be the diameter and the body to be spherical)$=0.036201\times0.5236Dd^3=0.018955Dd^3$. If we now substitute for D the specific gravity of cast-iron shot or shells$=7.000$, we have $W=7\times0.018955d^3=0.132566d^3$; and if for D we substitute the specific gravity of lead, $W=0.2142d^3$; and in case of powder, $W=0.01744d^3$.

For *diameters*, *weights*, and *charges*, see Tables, pages 126–131

43. *What are* RING *or* GROMMET *wads, and their use?*

They consist of a ring of rope yarn,* about 0.7 in. thick, with two pieces of strong twine tied across at right angles to each other. The size of the ring is the full diameter of the bore, in order that it may fit tight, and stop the windage. They increase the accuracy of fire, and are to be preferred when the object of the wad is merely to retain the projectile in its place, as in firing at a depression. They stop the windage best when placed behind the projectile. They may be attached to the straps, or to the projectile by twine, or may be inserted like other wads after the ball.

44. *How are* JUNK-WADS *made; and for what are they used.*

Wad-moulds for each calibre,—consisting of two cast-iron cylinders of different diameters set in oak, or of two strong pieces of oak, strapped with iron, and joined by a hinge,—are employed in their manufacture. The junk, after having been picked, is compressed by being beaten in the smaller mould with a *maul* and *cylindrical drift*—the latter nearly of the size of the mould—until it assumes the requisite dimensions; it is then taken out by raising the upper part of the mould, and closely wrapped with rope yarn, passed over it in the direction of the axis of the cylinder, and fastened by a few turns around the middle of the wad. It is then placed in the large mould, and again beaten with the maul and drift until its diameter is increased to that of the mould, when it is taken out and its diameter verified by a wooden gauge corresponding to the large shot-gauge of the calibre. These wads are used for proving cannon.

* They may also be made of *straw* formed into rings of the proper size, and wrapped with twine, and tied to the ball.

45. *Describe the process of loading field-shells.*

They are set up on their sabots, the charges measured out in the proper powder-measure, and poured in through a copper funnel. The fuze-plugs are then driven in with a mallet, allowing the tops to project about 0.1 in., care being taken not to split them. The holes in the plugs are then carefully reamed out, and stopped with tow-wads, which are pressed in firmly with a round stick.

46. *Describe the process of loading spherical case shot.*

The shot having been cleaned, the balls are put in. A stick with a less diameter than the fuze hole, and having a groove on each side of it, is inserted and pushed to the bottom of the cavity by working the balls aside. The shot is then placed in a sand-bath or oven, and brought to a proper temperature to receive the sulphur, which in a melted state is poured in to fill up the interstices between the balls; the shot is allowed to cool, and the sulphur to harden, when the stick is withdrawn, and the sulphur adhering to the sides of the eye and the surface of the shot is removed. If a fuze-plug and paper-fuze are to be used, the charge is poured in, and the plug inserted exactly as in case of a shell; but, if the Bormann fuze is to be used the charge is inserted and the stopper and fuze screwed into their places, care being taken before placing the fuze in position to puncture the covering of the magazine, so that the fire can communicate with the charge.

Spherical-case are now usually loaded by putting in the bullets and pouring melted sulphur or rosin in until the case is full. After the sulphur has cooled, the space for the powder is bored out by a cutter, which removes both the sulphur and portions of the bullets from the space. This is a quicker method, and gives a more compact projectile.

Case-shot for rifle guns are filled in a similar manner.

NOTE.—The object of the sulphur or rosin is to solidify the mass of bullets and prevent them from striking by their inertia against the sides of the case and cracking it when the piece is fired. Coal dust is sometimes used instead of sulphur or rosin. Round leaden balls, 17 to the lb. are used.

47 *What advantages does this mode of loading possess over the old one?*

In the old mode, besides a liability to accidents, if the powder remained in for any length of time before being used, it was ground up and became impaired. By the new mode the powder can be placed in the small cavity, and allowed to remain without fear of damage or danger, and be ready for use when required. Being, besides, in a compact mass, instead of scattered among the bullets, its power is much greater, and it acts more effectively in throwing the bullets outward from the centre.

48. *Describe the process of filling* MORTAR-SHELLS.

Having been inspected to see that they are clean, dry, and in good order, place them on a block made for the purpose, or on rings of rope, or in indentations in the floor of the magazine, or on the ground, with the fuze holes up. The charge measured out in a powder-measure is poured in through a funnel, and any incendiary composition, such as pieces of port-fire, rock-fire, &c., is inserted. In the mean time the fuze is cut to the proper length according to the range, by resting it in a groove made in the block, or inserting it in a hole made in a block or in a post, and sawing it across with the fuze-saw; or the fuze may be bored through with a gimlet perpendicularly to the axis at the proper point. The fuze is then tried in the fuze hole and should enter $\frac{3}{4}$ of its length. If it does not,

it may be reduced by rasping. The head of it is covered with tow to prevent the breaking of the composition, the fuze-setter placed on, and the fuze driven with the mallet until the head projects not more than 0.2 in. to 0.4 in. above the surface of the shell. These shells are generally filled and the fuzes driven in the battery magazines, as they are required.

49. *How are shells for* HEAVY GUNS *loaded?*

In the same way as Mortar-shells; but as paper fuzes inserted in wooden or bronze fuze plugs are used instead of wooden fuzes, the plug only is driven into its place, and stopped with tow after the bursting charge has been poured through it into the shell.

50. *How are condemned shot and shell marked?*

With an X, made with the cold chisel.

51. *How should balls be preserved?*

They should be carefully lacquered as soon as possible after they are received. When it becomes necessary to renew the lacquer, the old lacquer should be removed by rolling or scraping the balls, which should never be heated for that purpose.

52. *How should grape and canister shot be preserved?*

They should be oiled or lacquered, put in piles, or in strong boxes on the ground floor, or in dry cellars; each parcel marked with its kind, calibre, and number.

53. *How are balls piled?*

Balls are piled according to kind and calibre, under cover if practicable, in a place where there is free circulation of air, to facilitate which the piles should be made narrow, if the locality permits; the width of the bottom tier may be from 12 to 14 balls according to calibre.

Prepare the ground for the base of the pile by raising it above the surrounding ground so as to throw off the

water; level it, ram it well, and cover it with a layer of screened sand. Make the bottom of the pile with a tier of unserviceable balls buried about two-thirds of their diameter in the sand; this base may be made permanent: clean the base well and form the pile, putting the *fuze-holes* of shells *downwards* in the *intervals*, and not resting on the shells below. Each pile is marked with the number of serviceable balls it contains. The base may be made of bricks, concrete, stone, wood, or with borders and braces of iron.

54. *How should fixed ammunition for cannon be stored?*

Either in boxes or placed in piles, formed of two parallel rows of cartridges, with the sabots together in 4 tiers; chock the lower tier with strips of wood fastened with small nails; put a layer of tow 2 in. thick between the shot; let the piles rest on planks, if there is no floor, and cover them with tarpaulins; have the place swept, and the cartridge-bags brushed off. Leave a passage of 18 in. between the double rows, and keep them 2 feet from the walls. Fixed ammunition should not be put into powder-magazines, if it can be avoided; it should be kept in a dry place above the ground floor if practicable: the store-rooms should be always aired in fine weather, the piles should be taken down, and made up again every six months at most, the bags examined and repaired, and the damaged cartridges broken up. A ticket on each pile should show the number and kind of cartridges, the additions to the pile, and the issues.

55. *How should canister be piled?*

Like fixed ammunition, in 4 or 5 tiers. Empty canister in 10 or 12 tiers; the bottoms and covers separately.

56. *How should* CARTRIDGE-BAGS FILLED *be piled?*

Like fixed ammunition, or packed in boxes or barrels

57. *How should* LOADED SHELLS *be piled?*

On the ground floor of a secure building on planks, if the floor is not boarded; in 6 tiers at most; the fuzes of the lower tier in the vacant spaces between the shells; those of the other tiers turn downwards like the fuze-holes of empty shells; the piles should be covered with a tarpaulin. Loaded shells should never be put into magazines, except from absolute necessity.

58. *How should* FIRE-BALLS *be preserved?*

In a cool place, separated from each other by shavings or straw, if they are piled up, or they may be suspended by the handles, the bottom resting on a board or floor that they may not become deformed.

59. *How is the number of balls in a pile computed, of whatever form the pile may be?*

By multiplying the sum of the three parallel edges, by one-third of the number of balls in a triangular face.

60. *What is meant by the three parallel edges of the pile?*

Of the rectangular or long pile, they consist of the two largest bottom-rows and top-row; of the square pile, of two bottom-rows, and top-shot; and of the triangular pile of one bottom row, the shot at the opposite angle, and that at the top.

61. *How is the number of balls in a triangular face computed?*

Multiply the number in the bottom row, plus one, by half the number in the bottom row, for the number required.

62. *How is the number of balls contained in the top row of a rectangular pile calculated?*

One added to the difference between the long and short bottom rows will be the number required.

63. *How is the number of balls in an incomplete pile calculated?*

By first computing the number in the pile considered as complete, then the number of what the upper part ought to consist; and the difference of these piles will be the number contained in the frustum or incomplete portion.

DIAMETERS OF SOLID SHOT, SHELLS, AND CASE-SHOT.

Sea Coast.							Siege.		Field.			
20-in.	15-in.	13-in.	10-in.	12-in. rifle.	10-in. rifle.	24-pdr. howitzer.	4½-in. rifle.	8-in. howitzer.	3½-in. rifle.	3-in. rifle.	12-pdr.	12-pdr. mountain howitzer.
in.	in.	in.	in.	in.		in.	in.	in.	in.	in.	in.	in.
19.87	14.87	12.87	9.87	11.92	9.92	5.68	4.45	7.88	3.45	2.95	4.52	4.52

WEIGHTS OF SOLID SHOT, SHELLS, CASE SHOT, AND FINISHED CANISTER OF GUNS AND HOWITZERS.

	Sea Coast.							Siege.		Field.		
	20-in.	15-in.	13-in.	10-in.	12-in. rifle.	10-in. rifle.	24-pdr. Howitzer	4½-in. rifle.	8-in. Howitzer	3½-in. rifle.	3-in. rifle.	12-pdr.
	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.
Solid shot.........	1080	450	283	128	620	292	....	32.5	....	....	10*	12.3
Shells, not filled....	....	330	216	101.75	475	....	16.8	25.5	45	....	°9.5	8.34
Case-shot, do........	....	....	....	......	....	....	12.32	....	30.36	....	....	6.22
Do, filled.........	....	....	....	......	....	....	24.0	36*.	62	....	†9	12.17
Finished canister.....	....	....	....	......	....	....	20.5	....	53.5	....	†7.5	15
No. of shot in do.....	....	....	....	......	....	....	48	....	48	....	150	27

Hotchkiss 4½-in. solid shot weighs 32.5 lbs.; do, shell, 30 lbs.; do. case, 31.75 lbs.; Dyer's 4½-in. solid shot, 32.5 lbs.; do, shell, 25.5 lbs.; Hotchkiss 3-in. solid shot, 9.5 lbs.; do, shell, 8 lbs.; Absterdam improved shell, with brass sabot, for 4½-in. gun, weighs 23.5 lbs.

* Absterdam. ° Eureka. † Hotchkiss.

WEIGHTS OF MORTAR SHELLS.

15-in.	13-in.	10-in.	8-in.	Coehorn	Remarks.
lbs.	lbs.	lbs.	lbs.	lbs.	With heavy charges, the 10-in. Columbiad shell (weight 101.67 lbs.) is used with 10-in. sea-coast mortars.
......	216	88	44	17	

WEIGHTS OF PROJECTILES AND ROUNDS OF AMMUNITION FOR FIELD PIECES.

Weights,		3-in. rifle.				Gatling.		12-pdr. gun.	12-pdr. mountain howitzer.
		Hotchkiss.	Ordnance.	Absterdam.	Eureka.	Half inch	One inch		
		lbs.	lbs.	lbs.	lbs.	oz.	oz.	lbs.	lbs.
Shell		8.5	7.5	10.5	9	....	......	9.52	9.35
Case-shot		9	10.5	11.62	11.5	....	......	12.17	12.20
Canister		7.5	10	......	....	....	9.50	14.80	11.20
Solid shot		10	....	9.5	....	0.91	8	12.75	.....
Round of ammunition.	Shell	9.5	8.5	11.5	10	....	......	12.17	9.90
	Case shot	10	11.5	12.62	12.5	....	......	14.70	12.60
	Canister.	8.5	11	......	....	....	10.25	16.91	11.80
	Solid sh't	11	....	10.5	...	1.51	11.06	15.40	...

There is a shorter kind of Ordnance Canister, weighing 7.5 lbs. and carrying 100 balls.

CHARGES FOR CASE-SHOT FOR FIELD GUNS

	3-in. Rifle.				
	Hotchkiss.	Ordnance.	Absterdam.	Eureka.	12-pdr.
Bursting charge of powder, oz.	1	1	2	1	1
Number of lead balls in case-shot	24	40	58	42	76 to 82
Weight of loaded shot, lbs.	9	10.5	11.62	11.5	11.75 to 12.17

CHARGES FOR SHELLS FOR GUNS AND HOWITZERS.

Charge of Powder.	Sea Coast.						Siege.		Field.				
	15-in.	13-in.	10-in.	12-in. Rifle.	10-in. Rifle.	24-pdr. Howitzer.	4½-in Rifle.	8-in Howitzer.	12-pdr.	3-inch Rifle. Hotchkiss.	3-inch Rifle. Ordnance.	3-inch Rifle. Absterdam.	3-inch Rifle. Eureka.
	lbs. oz.	lbs. oz.	lbs. oz.	lbs. oz.	lbs. oz.	lbs. oz.	lbs. oz.	lbs. oz.	lbs. oz.	oz.	oz.	oz.	oz.
To fill the shell......	13.	1.0	3.4	15.0	7.0	1.0	1.8	2.9	0.8	3	10	8	8
To burst the shell....	....	1.0	1.6	....	....	0.8	....	1.0	0.5	....	....	....	. .
To blow out the fuze plug.......	....	....	0.10	....	....	0.2	....	0.4	0.1	....	...	....	....
For ordinary service..........	....	7.0	3.0	....	....	0.12	....	1.12	0.7	....	....	....	....

CHARGES FOR MORTAR SHELLS.

		13-in.	10-in.	8-in.	Coe-horn.
		lbs. oz.	lbs. oz.	lbs. oz.	lbs. oz.
Charge	of the shell filled with powder	11.0	5.0	2.9	1.0
	to burst the shell	6.0	2.0	1.0	0.8
	to blow out the fuze	0.6	0.5	0.4	0.2
Ordinary service charge.......	Cannon powder..	7.0	3.0	1.12	
	Incendiary match or other composition.	0.8	0.6	0.6	

PART X.

LABORATORY STORES.

1. *What is a* FUZE ?

A contrivance for igniting the bursting charge in a hollow projectile at any point of its flight.

2. *Into how many classes are fuzes divided?*

Into three, viz: the time fuze; the percussion fuze; and the concussion fuze.

3. *Describe the time fuze.*

It is composed of a case of paper, wood, or metal, inclosing a column of burning composition ignited by the charge in the gun; it burns for a certain time, at the end of which it communicates the flame to the bursting charge in the hollow projectile.

4. *For what projectiles is it used?*

For shells and rifle case-shot.

5. *Describe the percussion fuze.*

It receives no flame from the charge in the gun, but at the moment of impact, a flame is generated by means of fulminates, which produces the explosion of the charge in the shell. There are many varieties of this fuze, all consisting essentially of a brass or pewter *fuze-plug* or case which contains an iron or steel *plunger* terminating in a nipple which carries a common percussion cap; the plunger is held in its place at the lower end of the fuze-plug

by a collar screw, wire, or other device; when the projectile strikes, the plunger breaks loose, and by its inertia is driven forward with such force as to explode the cap and ignite the charge.

6. *For what projectiles is it used?*

For rifle-shells.

7. *What is a concussion fuze?*

It is a fuze that, like the time fuze, may be ignited by the charge in the gun, and the flame of the burning composition is admitted by means of some interior contrivance to the bursting charge in the shell at the moment it strikes the object.

8. *What is the radical difference between the concussion and the percussion fuze?*

The former explodes, no matter what point of the projectile strikes, whereas the latter requires the projectile to strike at or near the front end.

9. *To what projectiles is the concussion fuze applicable?*

To hollow spherical projectiles.

10. *What time fuzes are used in the U. S. service?*

Wooden, paper, the Bormann and the United States sea-coast fuzes.

11. *Describe the* WOODEN FUZE.

It consists of a conical plug of wood, of the proper size for the fuze-hole of the shell with which it is to be fired. The axis of this plug is bored out cylindrically, from the large, down to within a short distance of the small end, which is left solid. At the large end a cup is hollowed out, and the outside of the plug is divided into inches and parts, generally tenths, commencing at the bottom of the cup. The cylindrical space is filled with composition, pounded hard, and as regularly as possible, and the cup filled with mealed powder moistened with

whiskey or alcohol. The rate of burning is determined by experiment, and marked on a waterproof cap, which is tied over the cup. Knowing the time any shell is to occupy in its flight, the fuze is cut off with a saw at the proper division, and firmly set in the fuze-hole with a fuze-set and mallet. Say the fuze burns 5″ to the inch. If a shell be 10″ in reaching the mark, two inches of fuze will burst it as it strikes. It it takes 8″ to reach the mark, 1 $\frac{6}{10}$ in. should be cut off, etc.

12. *What is the disadvantage of this fuze?*

Its irregularity, it being very difficult to pound the composition so that equal lengths will burn in equal times. The shell may either burst too soon, and a great part of its effect be lost; or it may burst after burying itself in the ground; or it may burst after passing the proper point. This irregularity of burning is common to all fuzes where the composition is driven in successive layers in a column which burns in the same direction.

13. *With what shells is this fuze used?*

With Mortar shells.

14. *What is the composition of Mortar-fuzes?*

No.	Nitre.	Sulphur.	Mealed Powder.	Time of burning 1 in	Remarks.
1	2	1	3	3.8 sec.	For Siege Mortars.
2	2	1	2¼	5. "	For Sea-Coast "
3			1	2.2 "	For 8-in Howitzers.

15. *Are these fuzes always cut before being inserted in the shell?*

Generally they are; but they are sometimes *bored*

through at the proper positions instead of being sawed.

16. *Are they ever cut obliquely?*

Yes, when the fuze is so long as to render it likely that it will reach the bottom of the shell; for by cutting it perpendicular to the axis, the whole base of the wood might be driven in contact with the bottom of the shell, and prevent the lighted composition from setting fire to the bursting charge.

17. *Describe the paper time-fuze.*

It consists of a cylindrical column of *burning composition* packed in a paper case, gradually increasing in thickness from its lower to its upper or outer extremity; to insure ignition, it is primed with rifle-powder at the larger end. It is inserted at the time of loading the piece into a brass or wooden plug previously driven into the fuze hole of the shell. The composition has the same ingredients as gunpowder, the proportions being varied to suit the required rate of combustion; pure *mealed* powder gives the quickest composition; by adding certain proportions of sulphur and nitre, the composition burns more slowly. The rate of burning also depends upon the density of the composition and the purity and thorough mixture of the ingredients. These fuzes vary in length, burning from four to forty seconds; they are graduated in seconds on the outside of the case, and can be cut to a length corresponding to any intermediate time of flight.

18. *Describe the* BELGIAN *or* BORMANN-FUZE.

The fuze-case is made of metal (a composition of lead and tin), and consists, Fig. 2, first, of a short cylinder, having at one end a horse-shoe shaped indentation, *one* end only of which communicates with the magazine of the fuze placed in the centre by a channel filled with *rifle* powder.

This horse-shoe indentation extends nearly to the other end of the cylinder, a thin layer of the metal only intervening. This is graduated on the outside into equal parts representing seconds and quarter seconds (see Fig. 4.) In the bottom of this channel a smooth layer of the composition is placed, with a piece of wick or yarn underneath it. On this is placed a piece of metal; the cross section of which is wedge-shaped (see Fig. 3); and this, by machinery, is pressed down upon the composition, sealing it hermetically. The cylindrical opening, represented at *a* Fig. 2, is filled with musket powder and covered with a sheet of tin, which is soldered, closing the magazine from the external air.

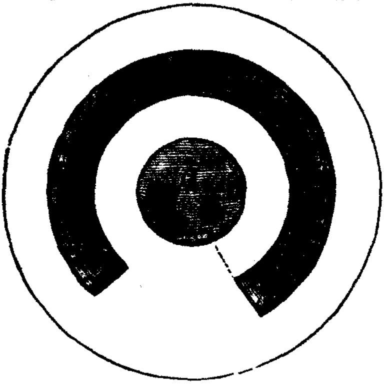

Fig. 2.

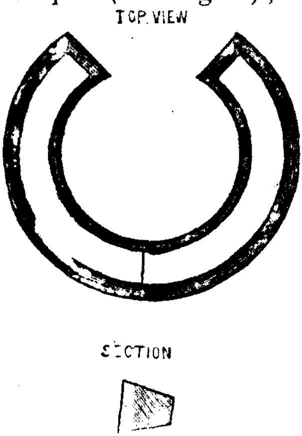

Fig. 3.

Before using the fuze, several holes are punched through this sheet of tin, to allow the flame to enter the shell. On the side of the fuze the thread of a screw is cut which fits into one cut on the inside of the fuze-hole, and the fuze is screwed into the shell with a wrench.

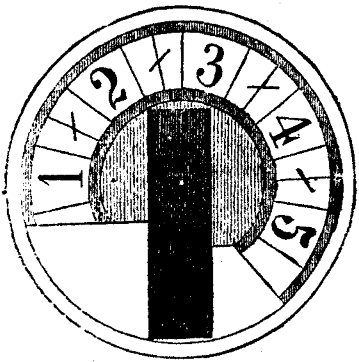

Fig. 4.

The thin layer of metal over the composition is cut through with a gouge or chisel, or even a pen-knife, at the interval marked with the number of seconds which we wish the fuze to burn. To prevent the metal of this fuze, which is soft, from being driven into the shell by the explosive force of the charge, a circular piece of iron, with a hole through its centre, and the thread of a screw on the outside, Fig. 5, is screwed into the fuze-hole before the fuze is inserted.

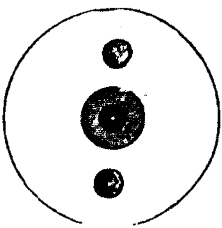

Fig. 5.

19. *For what projectiles is the Bormann fuze employed?*

For spherical case-shot.

NOTE.—The Wright fuze, a modification of the Bormann fuze, extends the time of burning to twelve or fourteen seconds.

20. *Mention one important advantage of this fuze.*

The shells can be loaded, all ready for use, and remain so any length of time, perfectly safe from explosion, as the fuze can be screwed into its place, and the composition never exposed to external fire until the metal is cut through.

21. *What is the only operation under fire required?*

To gouge through the metal at the proper point, with any kind of chisel, knife, or other instrument.

22. *Describe the* UNITED STATES SEA-COAST FUZE?

The paper case fits in a fuze-plug of bronze instead of wood. It fits the fuze-hole of the shell in the same way as the wooden plug, and is retained by the force of friction. A safety cap and primer combined have been adopted to prevent ricochets, especially over water, from extinguishing the fuze. A recess in the top, filled with priming composition, is covered, until the fuze is required for use, with a disk of lead or paper fitting accurately the opening. The fire is conveyed to the fuze composition through a crooked passage which is filled with priming, and prevents water from entering in sufficient quantity to extinguish the fuze.

For security, a small leaden plug is placed in the inner end of the fuze-plug, where it remains until it is driven out by the shock of the explosion.

When the shell is placed in the piece, nothing more is necessary than to remove the disk which covers the recess in the top.

23. *When are paper fuzes inserted?*

At the moment of loading the gun, and into wooden or brass *fuze-plugs* previously driven into the shell.

24. *What is a* PORT-FIRE?

It consists of a small paper case, filled with a highly inflammable but slow-burning composition, the flame of which is very intense and penetrating, and cannot be extinguished by water.

25. *What is it used for?*

Principally as an incendiary material in loading shells, and for communicating fire to the priming of guns when proving them.

26. *What does port-fire composition consist of?*

Of nitre, sulphur, and mealed powder, in different proportions. One kind is composed of

Nitre	65	parts.
Sulphur	22.5	"
Mealed powder.	12.5	"

A port-fire case, eighteen inches in length, filled with this composition, burns ten minutes.

27. *What are* PRIMING-TUBES, *and their use?*

Small pipes having a cup at one end, and filled with a composition for firing cannon.

28. *What tube is in general use in our service?*

The friction primer.

29. *Describe it.*

It consists of a short tube of metal inserted into a hole near the top of a longer tube, and soldered in that position. The short tube is lined with a composition made by mixing together one part of chlorate of potassa and two of sulphuret of antimony, formed into a paste with gum water. A serrated wire passes through the short tube and a hole opposite to it in the side of the long one, the open end of the short tube being compressed with nippers, and the wire at the end of the serrated part doubled under to prevent any displacement. The other end of the wire is doubled and twisted by machinery. The long tube is filled with rifle powder, its upper end being covered with shellac-varnish blackened with lamp-black, and its lower closed with shoemakers wax and dipped into varnish.

30. *Mention one great advantage of the friction tube?*

It gives an enemy at night no clue to the position of your piece, as does the lighted port-fire, or slow-match.

31. *What is* SLOW-MATCH?

A slow burning match prepared from hemp or flax slightly twisted, soaked in a strong lye, or in water holding in solution sugar of lead. Cotton rope well twisted forms a good match without any preparation.

32. *How long does slow-match prepared from hemp or flax burn?*

Four to five inches to the hour.

33. *What is the use of slow-match?*

It is used principally for the purpose of retaining fire in the shape of a hard-pointed coal, to be used in firing cannon, fire-works, &c. It was formerly used in field-batteries for lighting the port-fires with which the pieces were discharged; but both are now entirely superseded by the friction primer.

34. *What is* QUICK-MATCH?

It is a match made of threads of cotton, or cotton wick, steeped in gummed brandy or whiskey, then soaked in a paste of mealed powder and gummed spirits, and afterwards strewed over with mealed powder.

35. *How long does it burn?*

One yard burns in the open air thirteen seconds.

36. *What is the use of quick-match?*

To fire mortars, and sometimes in proving pieces. It is extensively used in priming all kinds of fire-works, such as fire and light balls, carcasses, rockets, priming tubes, &c., and in conveying fire very rapidly from one portion of a piece of fire-work to another.

37. *When used for discharging cannon, how is the quick-match set fire to?*

By a slow-match, port-fire, or any other convenient material.

38. *When used to prime carcasses, &c., how is it set on fire?*

By the flame from the piece.

39. *What is* VALENCIENNES *composition?*

A compound of 50 parts of nitre, 28 of sulphur, 18 of antimony, and 6 of rosin.

40. *What is its use?*

As an incendiary composition, in charging shells for the purpose of increasing their destructive property, by setting fire to buildings, shipping, &c.

PART XI.

PLATFORMS.

1. *What is a* PLATFORM ?

A strong flooring upon which a piece of ordnance, mounted on its carriage, is manœuvred when in battery.

2. *What is the object of a platform?*

To facilitate the service of heavy guns and mortars, and to insure accuracy of fire.

3. *Mention the kinds of platforms in general use in the service.*

Fixed platforms for casemate and barbette batteries in fortifications, which are constructed with the works; the siege-platform for guns and howitzers; and the siege-platform for mortars; the rail-platform; the ricochet-platform; and the platforms for sea-coast mortars.

4. *What properties should wooden platforms possess?*

Strength and portability.

5. *Are the pieces composing siege-platforms of the same or different dimensions?*

All of the same dimensions, viz: 9 feet long, 5 inches wide, and 3½ inches thick.

6. *What is the weight of each piece?*

About fifty pounds.

7. *What is the number of pieces in the siege-platform for guns and howitzers?*

Forty-nine in all, one being used as a *hurter* on the front part of the platform to prevent the carriage from running too far forward; and twelve for sleepers.

8. *What is the weight of this platform complete?*

Two thousand six hundred and one and a half pounds.

9. *Describe the method of laying a platform for a siege-gun or howitzer.*

First establish the centre line of the embrasure, and stretch a cord on this line from the middle of the embrasure to the rear. This is the *directrix* of the platform.

Lay the two outside sleepers parallel to this *directrix*, their outside edges being fifty-four inches distant from it. The four other sleepers are laid parallel to these, the edge of each fifteen and a half inches from the edge of the next. The upper surface of the front ends of these sleepers to be fifty inches on a vertical line below the sole of the embrasure.

They are laid with an elevation to the rear, of one and a half inches to the yard, or four and a half inches in their whole length. This elevation may be determined by placing a block four and a half inches high on the front end of the sleeper, and laying a straight-edge with a gunner's level on it from this block to the rear end, then so arrange the earth as to bring the level true in this position. The next set of sleepers are laid against and inside of the first, overlapping them three feet, having the rear ends inclined outwards, so that the outer edges of the exterior ones shall be each fifty-four inches from the directrix, and the spaces between the edges of the others the same as in the first set, viz: fifteen and a half inches from the edge of one to the edge of the next, all having the elevation to the rear of one and a half inches to the yard, and perfectly level across. The earth is then rammed firmly around these sleepers, and made even with their upper surface. The first deck-plank, with a hole through each end for the eye-bolts, is laid in place perpendicular to

the directrix, its holes corresponding with those in the sleepers. The hurter is placed on it, and the bolts driven through the corresponding holes in these pieces. The hurter should be so placed as to prevent the wheels from striking against the epaulment when the piece is in battery. If the interior slope has a base of two-sevenths of its height, the inner edge of the hurter should be two and a half inches from the foot of the slope. The other planks are then laid, each one forced against the preceding, the last plank having holes for the rear eye-bolts. By drawing out or driving in the outside sleepers, the holes through their rear ends are made to correspond with those in the last deck-plank, and the bolts are put in.

Drive stakes in the rear of each sleeper, leaving their tops level with the upper surface of the platform. Raise, ram, and level the earth in the rear of the platform, so as to have a plain, hard surface to support the trail when the recoil is great. The earth at the sides should be raised nearly as high as the platform, and well rammed, giving it a slight inclination outwards to allow the water to run off.

10. *What are the dimensions of this platform?*

Fifteen feet by nine feet.

11. *Why is the elevation to the rear given to this platform?*

To diminish the recoil and to permit the water to run off.

12. *Describe the platform for a siege mortar.*

It is composed of only *six* sleepers and *twenty-one* deck planks. It is laid level and the front and rear deck-planks are connected by eye-bolts to every sleeper.

13. *Give the dimensions and weight of this platform.*

Dimensions about nine feet deep by nine feet wide; and weight twelve hundred and twenty pounds.

14. *Describe the method of laying the rail-platform.*

The rail-platform for siege-mortars consists of three sleepers and two rails for the cheeks of the mortar-bed to slide on, instead of the deck-plank, and is very strong, and easily constructed and laid.

The pieces being notched to fit, are driven together at the battery, the distance between the centre lines of the rails being equal to that between the centre lines of the cheeks. The earth is excavated eight and a half inches, the depth of the sleepers, and the bottom made perfectly level. The directrix being exactly marked by stakes, the platform is placed in position, its centre line coinciding with a cord stretched between the stakes marking the line of fire. The earth is filled in as high as the upper surface of the sleepers, and firmly rammed; and the stakes are driven in the rear angles formed by the sleepers and rails, and one at the rear end of each rail.

15. *Mention the parts of the* RICOCHET-PLATFORM.

1 Hurter, 8 feet long.	8	in. wide,	and	8	in. thick.
3 Sleepers, 9 feet long,	5½	"	"	5½	"
2 Planks, 10 ft. 8 in. long,	13	"	"	2¼	"
1 plank, 7 ft. long,	13	"	"	2¼	"
1 piece of plank, 2½ ft. long,	13	"	"	2¼	"
18 stakes, 4 ft. long,	1¼	"	"	1¼	"

16. *What is the weight of this platform?*

Six hundred pounds.

17. *Describe the method of laying this platform.*

To lay this platform, place the hurter perpendicular to the line of fire, and secure it by four stakes, one at each end and two in front, 31½ inches from the middle towards each end; lay the three sleepers parallel to the hurter, the first 16 inches from the rear edge of the hurter, the second 43½ inches from the rear edge of the first, and

the third 43½ inches from the rear edge of the second. Lay the planks 31½ inches from the directrix of the platform to the centre of each plank. Place the piece of plank 60 inches from the rear edge of the last sleeper, and bed it in the ground. Place on the last sleeper and this piece of plank, *the* plank (7 feet long), its front end 106 inches from the rear edge of the hurter.

18. *Give the dimensions of parts of sea-coast Mortar platforms.* (See Table p. 147.)

19. *Describe the method of laying these platforms.*

FOR THE 13-INCH MORTAR.

A pit is dug 2 feet deep and about 18 feet square on the bottom. The earth on the bottom is well rammed and levelled. The dimensions of the 13-inch Sea-Coast Mortar platform are 15 feet by 15 feet by 2 feet 2 inches. The two-inch planking is laid level on the rammed earth perpendicular to the directrix. The cylindrical bolts are put in the sleepers, and the sleepers with bolt heads down, are laid compactly on, and perpendicular to the planking, and parallel to the directrix. As the deck-planks are laid, the bolts pass through the holes in them. The deck-planks are laid compactly upon the sleepers, perpendicular to the directrix. The nuts are put on the bolts and screwed down. Both the nuts and bolt-heads are counter-sunk. The iron plates are laid parallel to the directrix and screwed firmly with wood screws to the deck-planks, covering nine feet in the centre of the platform and leaving three feet on each side uncovered. The earth is then filled in and rammed compactly around the platform with a slight inclination outwards, so as to shed water. The platform for the new centre-pintle chassis is 17 feet square

DIMENSIONS OF PARTS OF SEA-COAST MORTAR PLATFORMS.

Names of Pieces.	13-inch.				10-inch.				Remarks.
	No. of pieces.	Length.	Width.	Thickness.	No. of pieces.	Length.	Width.	Thickness.	
		inch.	inch.	inch.		inch.	inch.	inch.	The timber for these platforms to be of oak or heart of yellow pine.
Deck Planks.......	15	180	12	12	12	144	12	9	
Sleepers...........	15	180	12	12	12	144	12	9	
Bolts...........	62	24	1	r'nd	49	18	1	r'nd.	
Nuts...............	62	1	2	2	49	1	2	2	
Wood Screws......	501	3	5-16	r'nd	204	3	5-16	r'nd.	
Iron Plates........	2	180	54	⅜	2	144	48	¼	
or Iron Plates......	3	180	36	⅜					
Planking....	15	180	12	2	12	144	12	2	

and the bottom of the pit must therefore be 20 feet square.

FOR THE 10-INCH SEA-COAST MORTAR.

The 10-inch platform is similar to the 13-inch described above, but its dimensions are 12 feet by 12 feet by 1 foot 8 inches, and the iron plates cover eight feet of the centre of the platform, leaving two feet on each side uncovered. The pit is one foot six inches deep by about 15 feet square on the bottom.

PART XII.

ARTILLERY CARRIAGES AND MACHINES.

1. *What is meant by artillery carriages?*

Carriages of every description employed in the artillery service.

2. *How are such carriages classified?*

Into two general divisions: first, those carriages on which artillery are mounted, either for firing or travelling; and secondly, such as are especially used for the transportation of artillery, ammunition, and stores.

3. *What is a gun-carriage?*

It is the machine on which a piece is mounted for manœuvring and firing.

4. *Into what classes may gun-carriages be divided?*

Into *movable* and *stationary* carriages.

5. *What is the use of* MOVABLE *carriages?*

They are used for the transportation of the pieces as well as for firing them, and are mounted on large wheels. They are furnished with limbers.

6. *Describe the* MOVABLE *carriage.*

It consists of two cheeks, connected together and with a stock by assembling bolts. The front part supports the

piece, and rests upon an axle-tree furnished with wheels, the rear end of the stock or trail resting on the ground.

7. *What are the* CHEKKS?

The parts of the carriage between which the piece is placed, and upon which the trunnions are supported.

8. *What is the wheel composed of?*

Of a nave into which the axle-tree enters; of a certain number of spokes fastened in the nave; and a circumference which is composed of a number of fellies equal to half the number of spokes.

9. *What is the* DISH *of a wheel?*

The inclination outward of the spokes, when fastened in the nave.

10. *What is the advantage of this obliquity of the spokes?*

It gives elasticity to the wheel, and protects it from the effect of shocks which would destroy it, if the spokes were in the same plane.

11. *What is the object of giving dish to a wheel?*

For the purpose of making the body of the carriage wider; to diminish the length of the axle-tree, thus increasing its strength; to throw the mud and water outside the wheels; and to keep the wheel close against the carriage, and prevent any tendency to run off the axle.

12. *How are movable gun-carriages distinguished?*

As field, mountain, and siege-carriages.

13. *What are the principal considerations to be kept in view in the construction of movable carriages?*

In firing, the carriage should yield to the recoil. Were it fixed immovably, it would soon be destroyed, no matter how great its solidity. Its weight should be proportional to that of the piece. If too heavy, it would soon be destroyed by the shocks of the piece. If too light, the

recoil would be immoderate. Its weight should always be less than that of the piece. A heavy piece upon too light a carriage will perform better service than the reverse arrangement, since the effort exerted by a piece depends upon its mass multiplied into the square of the velocity.

14. *What are the principal considerations to be kept in view in the construction of field-carriages?*

Lightness and strength combined, great mobility and flexibility, and a low centre of gravity, in order to surmount all difficulties in the field which must frequently arise while artillery is acting with other troops,—to resist the concussion in firing, and the severe jolting produced when moving rapidly over uneven ground.

15. *How many kinds of field-gun carriages have we?*

Three, viz: one for the three-inch rifle, which with slight modifications is adapted to the one-inch Gatling gun; one for the half-inch Gatling gun; and one for the twelve-pounder. The corresponding parts of these carriages differ only in their dimensions.

16. *In what respect are these carriages similar?*

In all, except that of the half-inch Gatling gun, the same kind of limber and the same size wheels, so that any limber or wheel may be used with any carriage.

17. *Describe these gun-carriages.*

They consist of two short cheeks of wood, bolted upon a stock and wooden axle-body, in a recess of which fits the iron axle on which the wheels are placed. The stock terminates in a *trail* and *trail-plate* which rests on the ground, and has on the end a strong ring called the *lunette*, which is placed on the pintle hook when the piece is limbered. In the stock is placed an elevating screw-box of bronze in which the elevating screw fits.

18. *Mention other parts of a field-carriage.*

Cap-squares, ear-plates, trunnion-plates, under-strap, elevating-screw, wheel-guard plate, axle-tree, trail-plate, trail-handles, prolonge-hooks, pointing-rings, washer-hooks lock-chain, sponge-chain, sponge and rammer stop, bolts, rings, bands, hooks, keys, straps, nuts and nails.

19. *What is the limber?*

It consists of a similar axle-body, axle, and two wheels, and on these rests a frame-work to receive the tongue. On top of the whole is an ammunition box, the top of which forms a seat for three cannoneers. In rear of the axle-tree is a *pintle-hook* to receive the lunette of the trail Connected with the frame work in front, is a fixed *splinter-bar* with four hooks, to which are attached the traces of the wheel-horses. At the extremity of the tongue are placed two pole-chains, by which the tongue or pole is held up, and a pole-yoke with two movable branches, to prevent, as much as possible, the pole from oscillating and striking the horses.

20. *What is the use of the limber?*

To facilitate the movements of the carriage. By means of it a considerable portion of ammunition and stores may be conveyed for the immediate use of the piece, some of the cannoneers may be seated on the boxes, and by the simple manner in which it is attached to the carriage, the greatest facility is afforded for coming into action, or in retiring.

21. *Are there any other advantages from the manner in which the gun-carriage and limber are connected?*

These two parts thus possess all the advantages of a four-wheel carriage, and the *freedom* of motion peculiar to each admits of their passing over ground uninjured, or without being overturned or strained, where any other four-wheel carriage would invariably fail.

22. *Give the total weight of a gun-carriage and limber equipped for service.*

3-inch. Six divisions in half-chest.	12-pdr.	Gatling Gun.	
		½-inch.	1-inch.
lbs.	lbs.	lbs.	lbs.
*3,791	3,978	1,546	3,302

23. *Describe the* MOUNTAIN ARTILLERY *gun-carriage.*

It is formed like the field-gun carriage, but much smaller, the cheeks not being formed of pieces distinct from the stock, but all three made of two pieces bolted together. The axle-tree is of wood, which lessens the recoil, and gives an elasticity to the whole carriage, better adapted to resist the shocks of firing. The wheels are but thirty-eight inches high. Ordinarily, over rough ground, the carriage is transported on the backs of mules; but where it is possible. a pair of shafts is attached to the trail to keep it from the ground, and the piece is drawn on its carriage by harnessing one of the pack mules to it. The ammunition is carried in ammunition boxes on the backs of mules.

24. *Describe the* PRAIRIE CARRIAGE.

The necessity for a small carriage for the mountain howitzer, when used on our western prairies, has led to the adoption of a special carriage for that service, with a limber attached as in a field carriage. This renders the

* When there are five divisions in each half-chest, the total weight i 3,648 lbs.

carriage less liable to overturn, and preferable in every respect to the two-wheeled one. The limber is furnished with two ammunition boxes, placed over the axle-tree, and parallel to it, and just wide enough for one row of shells and their cartridges.

25. *How many kinds of* SIEGE-GUN *carriages are used in our service?*

Three; one for the 4½-in. gun; another on which the 30-pdr. Parrott gun is now mounted; and the third for the 8-in howitzer.

NOTE.—These carriages are the old 12-pdr., 18-pdr. and *24-pdr. siege-gun carriages, a great number of which being on hand are utilized as above.

26. *In what respect are they similar?*

They are all constructed in the same manner, differing only in their dimensions. All the limbers and wheels are the same, so that they can be used in common.

27. *Describe this gun-carriage.*

It is similar in its construction to the field-carriage, but is joined to the limber in a different way. Projecting upwards from the limber and in rear of the axle-tree, is placed a pintle, which enters a hole made in the trail from the under side, and a lashing chain and hook keep the two parts together when once in position. The weight of the trail resting on the rear end of the tongue keeps this nearly horizontal, and relieves the horses of the weight of it, which, as it must be both long and heavy, is too much for the horses to carry.

* When the 8-inch howitzer is mounted on the 24-pdr. carriage, a quoin is used instead of the elevating screw, the howitzer being too short to rest on the screw.

The splinter-bar is, as in field carriages, stationary, but the traces of the next team are attached to a movable bar which is connected with the end of the tongue. The tongue is furnished with pole-chains, but no yoke, and the rest of the teams are harnessed as in field-artillery. The axle-trees are of iron, with axle bodies of wood, which last, by its elasticity, renders the shock from the piece less direct and violent.

On the upper surface of the cheeks, near the rear ends, are placed two projecting bolts which, with the curve of the cheeks, form resting places for the trunnions, when the piece is in position for transportation. They are called *travelling trunnion-beds.* When the piece, is in this position, its breech rests upon the bolster, which is a curved block of wood, bolted to the upper side of the stock. On each side of the trail, and perpendicular to it, a strong manœuvring bolt is placed to serve as places to apply the handspikes in manœuvring the carriage.

28. *What is the object of the travelling trunnion-beds?*

For the purpose of distributing the load more equally over the carriage.

29. *Mention the parts composing the limber.*

The fork, the splinter-bar, the hounds, the sweep-bar, the tongue, the pintle, the lashing-chain, the axle-tree (iron). The sweep-bar is of iron, and on it rests the trail, which by its weight keeps up the tongue.

30. *Give the weight of siege-gun carriages and limbers without* implements.

12-pdr., 3,641 lbs.; 18-pdr., 3,743 lbs.; and 24-pdr., 3,915 lbs.

31. *Why is it unnecessary for siege-carriages to have the same degree of mobility and flexibility as field-carriages?*

Because siege-carriages, are, properly speaking, trans-

portation wagons for use on roads, and never intended for manœuvring with troops.

32. *How many horses does the transportation of siege-guns require?*

Eight horses (four drivers.)

33. *What are* STATIONARY *gun-carriages used for?*

To fire the piece from, and not to transport it.

34. *For what service are these carriages used?*

For garrison and sea-coast pieces; although the siege-gun carriages just described may also be used in a fortification or garrison. Mortar-beds, to be described hereafter, are used either for siege or garrison service.

35. *What are the chief requisites for garrison and sea-coast carriages?*

Strength, durability, and facility in serving the guns, as they are intended only for the works of a place, coast-batteries, and situations where they are permanently fixed.

36. *Why should these carriages be required to possess great strength and durability?*

Unless made strong they would soon be shaken by the continued and rapid fire which the defence of a work may demand; and from their constant exposure to the weather they would soon decay if made of a very perishable material.

37. *Is the weight of garrison carriages a matter of great importance?*

It is of less importance in this class of carriages than in any other, as they are seldom removed from their situations; their weight adds but little to the labor of running them up.

38. *Mention the different* STATIONARY *carriages.*

The barbette front pintle carriage; the barbette centre pintle carriage; the casemate–carriage; and that for the

24-pdr. iron howitzer, called the flank casemate-carriage; and the carriage on which the mortar is mounted called its *bed*. All these, except the *flank casemate-carriage*, are of wrought iron, the *latter* being made of wood.

NOTE.—The 13-in. mortar is now mounted on a centre pintle carriage in the following manner, viz.: The mortar is mounted on the usual bed, and this upon a chassis resting on its platform.

39. *What is a* BARBETTE *carriage?*

It is a carriage of the stationary class, on which a gun is mounted to fire *over* a parapet; and a barbette gun is any gun mounted on a barbette carriage.

40. *Of how many parts are sea-coast carriages composed?*

Of a gun-carriage and chassis.

41. *Describe the wrought-iron gun-carriage.*

It is composed of two *cheeks*, held together by two plates of boiler iron called the *front* and *rear transoms*. Each cheek is formed of two pieces of boiler iron cut to a triangular shape, separated at the edges by interposing the vertical portion or web of a T shaped bar. The horizontal branches project over each side to form a double rim, which gives stiffness to the cheeks. Flat bars of iron are also placed between the plates at suitable intervals to stiffen the cheeks in the direction in which the weight and recoil of the piece bear upon them. All these parts are held together by screw-bolts. The motion of the carriage to and from battery is regulated in the 8 and 10-inch carriages by a pair of eccentric truck wheels, which work on an axle-tree placed underneath and a little in front of the centre of the trunnions. When it becomes necessary to check the recoil of the gun-carriage, the wheels are thrown *out of gear* by means of a handspike inserted in the socket attached to the end of the axle-tree, and the carriage

moved on sliding friction. When the gun is to be moved into battery, the wheels are thrown *into gear*, in a similar manner, and the front of the carriage moves on rolling friction.

The manœuvring wheels mentioned above are fixed on the projecting ends of the axle-tree, the axis of the wheel being eccentric with the axis of the axle-tree. These eccentrics are so arranged that when the centres of the wheels are at their lowest points the surface of the wheels bear on the rails of the chassis and raise the gun-carriage from it; and when the centres are at their highest points the surfaces of the wheels do not touch the rails, and the gun-carriage is in contact with them. In case there is no socket connected with the end of the axle-tree, the wheel is thrown into or out of gear, that is, made to bear on the rail of the chassis, or relieved from it, by turning the axle-tree with a wrench placed on the hexagonal end. In the 15-in. carriage there are two pairs of manœuvring wheels, one pair being placed in front as above described, and the other pair near the rear end of the carriage.

The elevation and depression are given by a lever, the point of which works in a ratchet cut in the breech of the piece. The fulcrum* is made of cast iron and rests on the rear transom of the gun-carriage. It has several notches for adjusting the position of the elevating bar.

42. *Describe the chassis.*

The chassis is the movable railway on which the gun-carriage moves to and from battery. It is composed of two wrought-iron rails inclined 3° to the horizon, and united by transoms, as in the gun-carriage. In addition to the transoms, there are several diagonal braces to give stiffness to the chassis.

* *It* is so named in the Ord. Manual, but in the Heavy Artillery tactics and in Appendix No. 2 of this Hand-book it is called the "ratchet-post."

For the 10-inch and smaller carriages, the chassis rails are single beams of rolled iron, 15 inches deep; for all calibres above, the rails are made of long rectangular pieces of boiler plate and T iron, in a manner similar to that of the cheeks of the gun-carriage. In order to move the carriage horizontally in the operation of aiming the piece, the chassis is supported on traverse wheels which roll on circular plates of iron, fastened to a bed of solid masonry, called the *traverse circles*. The motion of the gun-carriage is checked front and rear, by pieces of iron bolted to the top of the rails, called *hurters* and *counter hurters;* and it is prevented from slipping off sideways by *friction rollers* and *guides*, which are bolted to the cheeks and transoms.

In a late modification of the 15-inch carriage, the front eccentric axle is replaced by an ordinary one, dispensing with axle-pawls and friction bands, the handspike pawls are made double instead of single, with a spring to keep them out of the ratchets, the front set of transoms and diagonal braces are removed from the chassis, and pneumatic or hydraulic buffers to check the recoil are put in with thick braces. When the rear manœuvring wheels are *out of gear*, the top carriage touches the rails of the chassis and moves on sliding friction, aud when they are in *gear* the front wheels are also made to touch the rails and the top carriage moves on rolling friction. To prevent the rear manœuvring wheels from working *out of gear* while the gun is being run from battery, or jumping *in gear* when the gun is fired, pawls are provided for locking the rear axle. When no pawls are provided for locking the eccentric axle, it is often necessary for one cannoneer to remain embarred in the axle socket to prevent the axle from flying *out of gear*. The 15 in. carriage allows an elevation of about 32° and a depression of about 6° unless when fitted with

pneumatic buffers when no more than 25° elevation can be given. With the hydraulic buffer which passes along the centre of the chassis, the elevation is still further diminished.

43. *What is the pintle and where is it placed?*

It is the central piece around which the chassis is traversed. In the centre-pintle carriage it is in the centre of the chassis, but in the front pintle carriage it is in the centre of the front transom. It is a stout cylinder of wrought iron inserted in a block of stone, if the battery be a fixed one; or it is secured to cross pieces of timber bolted to a platform firmly imbedded in the ground, if it be of a temporary nature. In casemate batteries the pintle is placed immediately under the throat of the embrasure, and the chassis is connected with it by a stout strap of iron, called the *tongue*.

Casemate carriages differ from barbette carriages in being much lower, but their mode of construction is essentially the same.

44. *Where are the handspikes applied in manœuvring these carriages?* To holes in the circumference of the traverse and manœuvring wheels.

45. *Why does the chassis slope towards the front?*

In order to diminish the recoil, and aid in running the piece into battery.

46. *What guns go on the same carriage?* The 10-inch rifle and the 13-inch smooth bore on the 13-inch carriage; and the 12-inch rifle and 15-inch smooth bore on the 15-inch carriage. The 20-inch gun has a separate carriage.

47. *What carriage is preferable for the barbette batteries?*

The centre-pintle carriage as affording a much greater horizontal field of fire.

48. *What are the weights of top carriage and chassis of the 15-inch gun carriage?*

Weight of top carriage with air cylinder attachments, ...	5,800 lbs.
Weight of chassis, (centre pintle) . .	9,466 lbs.
" " " with air cylinder	15,450 lbs.
" " (front pintle) with geared traverse wheels, ...	11,022 lbs.
" of chasiss (front pintle) with air cylinders and geared traverse wheels, .	17,000 lbs.

49. *How many kinds of* SIEGE-MORTAR *beds have we?*
Three; the 8-in., 10-in., and the Coehorn.
50. *Which of these are alike?*
The first two, differing only in dimensions.
51. *Describe these beds.*

They are made of wrought iron and put together after the manner of the sea-coast gun carriage. The different parts are the cheeks, which, like those of the gun carriage, are triangular in shape, and two transoms connecting the cheeks together. At the end of each cheek are projections, called front and rear notches, underneath which the cannoneers embar with their handspikes to move the bed on the platform; there are also two front and two rear manœuvring bolts for the same purpose. The elevation and depression are given as in the gun carriage, by embarring with the iron elevating bar through the fulcrum* into the ratchets on the breech of the mortar.

Sea-coast mortar beds have eccentric truck wheels for manœuvring the mortar bed on the platform, and manœuvring bolts are omitted.

52. *Describe the centre-pintle carriage upon which the* 13 *inch mortar is mounted.*

The mortar is mounted on the usual bed now become

*It is so named in the Ord. Manual, but in the Heavy Artillery tactics and in Appendix No. 2 of this Hand-book it is called the "ratchet-post."

the top carriage, and this upon a chassis resting on its platform. The top carriage has a crane attached to the left cheek, and to the inside of the right cheek is attached a pawl worked from the front, for locking the eccentric axle in and out of gear, and the carriage is strengthened by an additional rear transom about 5 inches wide, the pipe being omitted. The chassis has the usual appliance for throwing this class of carriages into gear, and in addition an eccentric axle placed at right-angles to, and supported by, a double front transom, and carrying a traverse wheel, by means of which motion is communicated to the chassis. The chassis is otherwise transomed and braced in accordance with the system. The chassis weighs 2,000 lbs., and the chassis rails are 190 inches long, and 10 inches high in front, and 15¼ inches in rear.

53. *Describe the* COEHORN *mortar-bed.*

It is made of a block of oak-wood, in one piece, or two pieces joined together with bolts. A recess for the trunnions and part of the breech is made in the top of the bed; and the trunnions are kept in their places by plates of iron bolted down over them. Two iron handles are bolted to the bed on each side, by which four men can carry the bed with the mortar in its place, the entire weight being only 296 pounds.

54. *Where is the* FLANK CASEMATE *carriage employed?*

It is especially adapted to the mounting of the 24-pdr. iron howitzer in the flanks of casemate-batteries, for defending the ditch.

55. *Describe the wooden gun-carriage.*

The cheeks are made of white oak, and connected by two iron transoms, the front one projecting below the cheeks, and resting on the chassis with a projection on the bottom of it, fitting in between the rails. The bottom of

the trail has the same slope as the upper surface of the chassis on which it rests; so that when its eccentric-roller is out of gear, the rear parts of the cheeks fit the rails. The remaining portion of the bottom of the cheek makes an angle with the rail, and has in front a fork, and a roller which runs on the rail of the chassis when the eccentric is in gear. Each cheek has on the side a trail-handle and a manœuvring-ring. In rear of the rear transom is placed an eccentric-roller, having a projection in the middle of it, just large enough to fit in between the rails of the chassis, and guide the trail of the carriage. When this *roller* is in gear, the weight of the trail rests upon *it*, while that of the front part of the carriage is thrown upon the front rollers, and the piece is then easily run in and out of battery; but the roller being out of gear, as when the piece is about to be fired, the weight rests upon the rear part of the cheeks and the front transom, and sliding friction is brought into play to diminish the recoil. Cap-squares are used with this carriage.

56. *Describe the chassis.*

It consists simply of two rails 3 inches apart, and joined by four transoms and assembling-bolts. Hurters on the rear ends of the rails only are used, as the bottom projection of the front transom prevents the carriage running too far into battery. The front end of the chassis rests on the sole of the embrasure. The end is provided with a pintle-plate and a strap of half-inch iron through which the pintle passes to the masonry beneath. The rear of the chassis is supported by an iron prop, the lower end of which is attached to two traverse-wheels.

57. *What carriage is used for conveying ammunition for a field battery?*

The CAISSON.

58. *Describe it.*

A four-wheeled carriage, consisting of two parts, one of which is a limber similar to that of the gun-carriage, and connected in a similar way by a wooden stock and lunette. On the axle-body of the rear part, and parallel to the stock, are placed three rails upon which are fastened two ammunition boxes, one behind the other, and similar to the one on the limber; so that the caisson has three ammunition boxes which will seat nine cannoneers. The interior compartments of the ammunition boxes vary according to the nature of the ammunition with which they are loaded. In rear of the last box is placed a spare wheel axle of iron, with a chain and toggle at the end of it. On the rear end of the middle rail is placed a carriage hook similar to a pintle hook, to which the lunette of a gun-carriage whose limber has become disabled, may be attached, and the gun carried off the field.

The caisson has the same turning capacity and mobility as the gun-carriage, so that it can follow the piece in all its manœuvres, if necessary. It also carries a spare wheel, spare pole, &c.

59. *Give the total weight of a caisson eqnipped for field service.*

3-in. Six divisions in half chest.	12-pdr.	Gatling gun.	
		½-in.	1-in.
lbs. * 3,819	lbs. 3,815	lbs. 2,065	lbs. 3,536

* When there are five divisions in each half-chest, the total weight of the caisson is 4,245 pounds.

60. *What provision is made for repairing the carriages of a field-battery when required?*

Every field-battery is provided with a FORGE.

61. *Describe this wagon.*

It consists, besides the limber, of a frame work on which is fixed the bellows, fire-place, &c. Behind the bellows is placed a coal-box, which has to be removed before the bellows can be put in position. In the limber box are placed the smith's tools, horse-shoes, nails, and spare parts (iron) of carriages, harness, &c.

62. *What is the weight of the Forge equipped for field service?*

3,383 pounds for the battery; and 3,370 pounds for the reserve.

63. *Describe the* BATTERY-WAGON.

It consists, besides the limber, of a long-bodied cart with a round top, which is connected with the limber in the same way as all other field carriages. The lid opens on hinges placed at the side; and in the rear is fixed a movable forage-rack for carrying long forage. One of these wagons accompanies each field-battery, for the purpose of transporting carriage-maker's and saddler's tools, spare parts of carriages, harness and equipments, and rough materials for replacing different parts.

Both this and the forge are made of equal mobility with the other field carriages, in order to accompany them wherever they may be required to go.

64. *What is the total weight of a battery-wagon equipped for field service?*

3,574 pounds, exclusive of forage, for the battery; and 4,915 pounds for the reserve.

65. *How many kinds of wheels are employed for field carriages?*

Three: No. 1, for the 3-inch rifle and 1-inch Gatling gun-carriages, for the caissons, forge, battery-wagon and all limbers, except that of the ½ inch Gatling gun-carriage; No. 2, for the 11 pounder gun-carriage; No. 3 for the ½ inch Gatling gun-carriages, caissons and limbers.

66. *In what respect are wheels No.* 1 *and* 2 *similar?*

They are of the same form and height, and they fit on the same axle-tree arm. Their height is 57 inches, and each wheel is composed of 14 spokes and 7 fellies.

67. *How do they differ?*

In the dimensions of their parts, and in strength and weight.

68. *What is the weight of these wheels?*

No. 1, 180 pounds; No. 2, 196 pounds.

69. *Give the weight and height of wheel No.* 3.

Weight, 87½ pounds, and height 45 inches.

70. *What are the weight and height of a wheel of siege gun-carriages and limbers?*

Weight 404 pounds, and height 60 inches.

71. *What are the weight and height, and number of spokes and fellies of a wheel of the mountain artillery gun-carriages?*

Weight 60 pounds, and height 38 inches. The weight of a wheel of the prairie-carriage and limber is 69 pounds, and height 42 inches. These wheels have 12 spokes and 6 fellies.

72. *Give the track of the wheels of artillery carriages.*

The track of the wheels of all artillery carriages (the mountain howitzer and prairie carriages, and the ½ inch Gatling gun-carriage excepted) is 60 inches. In case of the mountain howitzer carriage the track is 30.2 inches; that of the prairie-carriage is 42.5 inches, and that of the ½ inch Gatling gun-carriage is 43 inches.

73. *What is the* PORTABLE FORGE *designed for?*

Service in a mountainous country, where wheeled carriages cannot travel, for the purpose of making repairs not only for the artillery, but for all other arms of service taken on such expeditions.

74. *What is the* MORTAR-WAGON *designed for?*

The transportation of siege-mortars and their beds, or of guns, or large shot and shells.

75. *Describe this wagon.*

The limber and wheels are the same as those of the siege gun-carriage. The body consists of a platform of rails and transoms, resting on an axle-tree, the two middle rails being prolonged to form the stock; six stakes or standards are inserted in sockets on the side of this platform and used to secure the load. The side rails are prolonged to the rear and furnish pivots for a roller placed immediately in rear of the platform. This roller by the application of hand-spikes, is used in loading the wagon; the guns, mortars, &c., being drawn up on the stock.

A muzzle bolster on the stock near the limber, and a breech-hurter near the hind part of the wagon, are provided and used when long pieces are transported on it.

Mortars are usually carried mounted on their beds.

76. *What is the weight of the mortar-wagon?*

The weight (carriage and limber complete without implements), is 3,185 lbs.

77. *What is the use of the* HAND CART?

For the transportation of light stores in siege and garrison service.

78. *Describe it.*

It consists of a light body with shafts, mounted on two wheels. The shafts are joined together at the ends, and supported immediately in front of the body by iron legs. It weighs 181 lbs.

79. *What is the use of the* HAND SLING-CART?

It is used in siege and garrison service for transporting artillery short distances.

80. *Describe it.*

It is a two-wheeled carriage made entirely of iron, except the pole which is of oak. The axletree is arched to make it stronger, and connected with the pole by strong wrought iron straps and braces. In the rear of the axle a projection is welded to receive the end of a strong hook. The end of the pole terminates in a ferule and an eye. The eye is for the purpose of attaching to the cart, when necessary, a limber or a horse. The diameter of the wheels is 6 feet.

81. *How great weights can be transported by this cart?*

It should not be used *habitually* for heavier weights than about 4000 lbs., but in case of necessity a 24 or 32-pdr. gun may be transported on it. For heavier guns or material, the large *sling-cart* drawn by horses or oxen should be used. *This* cart is wooden throughout, and the diameter of the wheels 8 feet.

82. *What are the weights of the hand sling-cart and the large sling-cart?*

Hand sling-cart weighs 1,115 lbs.; large sling-cart 2,282 lbs.

83. *What is the* FIELD AND SIEGE GIN *and its use?*

It consists, like all gins, of two legs and a pry-pole, a windlass, sheaves, pulleys, and a fall or rope, and is used for mounting or handling guns, or other heavy bodies, in the field or in the trenches of a siege. The legs are about 14½ feet long, and the height of the gin about 12 feet. It weighs 615 lbs.

84. *How does the* GARRISON GIN *differ from the field and siege gin?*

It is heavier and stronger, as it is used for mounting heavier guns, and has not to be transported like the other with an army in the field. The legs are longer and the gin higher than the other. Its weight is 1,250 lbs., and the legs are about 21 feet long.

85. *Describe the* CASEMATE GIN.

It does not differ from the garrison gin except in its height (which is about that of the field and siege gin), and the thickness and strength of the parts. Its weight is 979 lbs.

86. *How many kinds of hydraulic jacks are used for artillery purposes?*

Two, viz.: the lifting and pulling jacks. They are employed in moving heavy guns through very short distances, and are usually of 15 or 30 tons capacity.

87. *Give the weight and dimensions of these jacks.*

	Height.	Lift or Stroke.	Weight filled.	Weight of Shoe.
Kind of Jack.	Inches.	Inches.	Pounds.	Pounds.
30 ton lifting Jack....	20	12	230	90
15 ton lifting Jack....	20	12	140	50
30 ton pulling Jack...	62	18	310	

88. *What force must be applied to the lever of these jacks?*

No greater force than that of one man (provided he applies a power of about 150lbs.) need ever be applied to the lever of either the lifting or the pulling jack, since that force is amply sufficient to work the jack to its full capacity.

89. *Explain the mode of filling the lifting jack.*

Remove the small screw in the head, having the piston or ram quite down; fill the jack through the screw-hole in the head with winter strained sperm oil, or alcohol, or whiskey, adding to the latter (if liable to freeze) a table-spoonful of sperm oil, work the lever while pouring in the liquid until the ram, or piston, is up to its full stroke; when this occurs the jack is filled sufficiently. Then reverse the lever and push the ram, or piston, back to the bottom of the cylinder, and replace the screw in the screw-hole in the head of the jack. This screw is not intended to fit *tight*, and must not be screwed tight home after filling the jack. Be careful that no dirt gets into the head of the jack, while filling.

The liquid may consist of equal parts of alcohol and water, or equal parts of whiskey and water; but these liquids should not be used when the temperature is at, or likely to be at, freezing point. Kerosene oil, or water unmixed with either alcohol or whiskey must never be used to fill the jack. Spirits of turpentine is also an unsuitable liquid for use in these jacks.

90. *Explain how to fill the pulling jack.*

With the iron key, unscrew and remove the screw at each end of the cylinder; if the piston is not down, push it home; fill through the two screw holes with the same liquid as is used on the hydraulic lifting jack; and replace the screws, screwing them home, but not too tight.

91. *Explain how to lift an object with the lifting jack.*

Place the head of the jack under the object to be lifted. If the object is too near the ground to admit of this, use the iron claw, placing one of its hooks under the object and the other (which has a dowel) over the head of the jack. Insert that end of the lever which is squared (or made with

a journal), and has a projecting shoulder, into the mortice or slot of the jack, the projection of the shoulder *downwards* (or underneath), and pump until the object is raised to the required height. If this height is greater than the full stroke of the piston or ram, block up the object to be lifted, reverse the lever so that the projection of the shoulder is upwards or above, press upon it until it is at the bottom of its stroke, and then push the piston or ram down to the bottom of the cylinder; block the jack up higher; then reverse the lever, and proceed to raise the object as in the first instance.

It sometimes happens that the piston or ram cannot be pushed down after it has been run up to its full height or stroke, this difficulty can be overcome by slacking by a few turns the small screw in the head of the jack, and thus allowing the air with which the jack is filled to escape.

Sometimes the jack fails to work in consequence of the valve sticking in its seat, this difficulty can be overcome by striking the lever a few sharp blows up and down with a wooden mallet or stick, which will jar the valve and cause it to resume its action.

The lifting jack can be used standing at any angle between 10 and 90 degrees above the horizontal; but great care must at all times be used that the support for its base is secure, and that its head is not permitted to slip from under the object to be raised.

92. *Explain how to lower an object with the lifting jack.*

Place the head of the jack securely under the object to be lowered, with the piston or ram run up to the distance to which the object is required to be lowered, press down the lever as far as it will go, take out the lever and reverse it so that when put back in the slot or mortice, the

projection of the shoulder of the lever is upwards (or above); then with a slight pressure of the hand push the lever downwards cautiously, when the object will commence to lower and will continue to lower as slowly as desired. By giving the lever a slight push upwards the lowering can be arrested at any point. The object must not be lowered too fast, nor the lowering checked too suddenly, or the jack will cease to work.

93. *Explain how to use the pulling jack.*

Secure one end of the jack to some fixed object (the end nearest the pump is preferable); unscrew with the key the valve in the pump two or three turns, and pull the jack down or stretch it apart, attach the free end of the jack to the object to be moved; shut the valve by screwing back the two or three turns that were unscrewed; attach the long lever and pump away at it until the object is moved as desired. When there is not room for the long lever, the pump can be worked by the short lever. If the jack does not start at once, slack the screw in the cylinder (close to the pump, which the same key fits), until a drop or two of the fluid comes out; as soon as this occurs turn the screw immediately back. If the piston or ram will not run out to its entire length or stroke, place the jack in a horizontal position, take out the screws at each end of the cylinder, and fill through both holes with the usual liquid.

The pulling jack can be used to pull or to lift at any angle between the horizontal and the perpendicular, but the direction of its force must always be a straight line, and the force pump must always be at the lowest end when the jack is used in any other way than horizontally. When the pulling jack is in use the lever joints must be well oiled, and kept free from dirt. When the pulling

jack is not in use the piston rod must be kept in, and when the jack is hung up, the end where the pump is, must always be downward.

NOTE.—The foregoing in relation to hydraulic jacks is taken from "Artillery School Circular," No. 7, 1874.

PART. XIII.

PRACTICAL GUNNERY.

1. *How may the initial velocity of a shot or shell be ascertained?*

It may be determined approximately by firing the gun, the axis being horizontal, at a target and measuring the *distance* of the point struck below the point where the axis of the gun produced would pierce the target. *This* is the vertical distance fallen through by the ball in the time of passage from the muzzle to the target, and the time in which it falls through this distance is given by the formula

$$t=\sqrt{\frac{2s}{g}}$$

in which t represents the time, s the vertical space fallen through, and g the force of gravity. The distance to the target divided by this *time* gives the initial velocity approximately.

2. *What is the ratio of the initial velocities of projectiles when the weight of the powder and projectile alone vary?*

The initial velocities are *directly proportional to the square root of the weight of powder divided by the square root of the weight of projectile.*

3. *What is the ratio of the initial velocities of projectiles when of different weights, but fired with similar charges?*

The initial velocities are inversely as the square roots of their weights.

4. *What is the ratio of the initial velocities of projectiles of equal weights when fired with different charges of powder?*

The velocities are directly as the square root of the charges.

5. *What causes affect initial velocity?*

The size and position of the vent, the windage, the length of the bore, the form of the chamber, the diameter and density of the projectile, the windage of the cartridge, and the form, size, density, and dryness of the grains of powder, and the barometric, thermometric, and hygrometric states of the atmosphere.

6. *Mention some of the instruments employed to determine initial velocity.*

The gun-pendulum, the ballistic-pendulum, electro ballistic machines, the Schultz chronoscope and the "Le Boulengé" chronograph. The last two are now mostly used in service. The various plans in use differ only in the manner of recording and keeping the time of flight.

7. *Does a shot or shell continue at the same uniform velocity during its flight?*

The velocity decreases as the distance increases, in a proportion a little higher than the squares of the velocities throughout.

8. *What causes a decrease of velocity of a shot?*

The resistance of the air, which varies as the square of the velocity of the shot.

9. *With projectiles of different diameters, and equal velocities, to what is the resistance of the air proportional?*

Their surfaces, or the squares of their diameters.

10. *Would the velocity of a projectile be increased by lengthening the gun?*

Only up to a certain point; in a proportion which is nearly the mean ratio between the square and cube roots of the length of the bore. It is found that the velocity given by long guns is reduced to an equality with that of

short guns within a short distance from the muzzle when fired with similar charges.

11. *Would the velocity of a projectile be increased by entirely preventing the recoil, or by adding greatly to the weight of the gun?*

In neither case would any sensible effect be produced on the velocity.

12. *Would the velocity of a projectile be increased by using a larger charge of powder?*

Only to a certain point, peculiar to each gun; by further increasing the charge the velocity would be gradually diminished; yet the recoil is always increased by an increase of charge.

13. *To what is the final velocity of a projectile falling in the air proportional?*

It is directly proportional to the product of its diameter and density, and inversely proportional to the density of the air.

14. *How is the retarding effect of the air upon the larger and denser projectiles?*

It is less, and consequently the range greater.

15. *How is the retarding effect of the air upon an oblong projectile as compared with its effect on a spherical one?*

For the same calibre, an oblong projectile will be less retarded, and consequently with an equal or even less initial velocity its range will be greater.

16. *What is meant by the time of flight of a shot or shell?*

The time during which it is passing through the air from the piece to the first graze.

17. *When firing with common shells at 45° elevation, how is the time of flight found?*

Extract the square root of the range in feet and divide

by 4, or divide the range in feet by 16 and extract the square root of this quotient.

NOTE.—Range in feet$=\frac{1}{2}gt^2\times$cotangent elevation.
$=16t^2\times$cotangent elevation.
$=16t^2$ where the elevation is 45°.

Or $t=\frac{1}{4}\sqrt{\text{range in feet for elevation } 45^\circ}$.

18. *Having the time of flight, how is the range ascertained?*

Multiply the square of the time of flight by 16 for the range in *feet*, (the elevation being 45°).

19. *What is meant by the penetration of projectiles?*

The depth to which they are forced when fired into any resisting medium.

20. *Give the law of penetration of spherical projectiles.*

Their penetration when of the same size, with different velocities or charges, is nearly as the squares of the velocities; when of different sizes the penetration will be proportionate to their diameters multiplied by the density, and inversely as the tenacity of the medium.

21. *What is the depth of penetration of projectiles fired from the 4½-in. siege-gun?*

About the same as that of the 30-pdr. Parrott gun (see page 189).

22. *What is the depth of penetration of a projectile fired from field pieces?*

Fired at the distance of 500 or 600 yards, the penetration will be from 4½ to 6 feet in parapets recently constructed, will traverse walls of ordinary construction; but a 12-pounder is necessary to make a breach in walls of good masonry and of 4 feet in thickness, and in this case

the position of the battery must be favorable, and the operation a slow one.

23. *How may the perforation of iron plates be determined?*

By the following formulæ of Capt. Noble, viz.:

$$z = at^2$$

$$z = \frac{WV^2}{452617 \times d}$$

in which

z=number of foot tons per inch of shot's circumference.
W=weight of shot in pounds.
V=velocity of impact in feet.
d=diameter of shot in inches.
t=thickness of plate in inches.
a=1.384.

To apply this to an example, let us take the 20-in. Rodman gun in which W=1070 lbs., V=1400 feet (weight of charge of powder being 200 lbs.); then by substitution we will have

$$z = \frac{1070 \times \overline{1400}^2}{452617 \times 19.95} = \frac{2097200000}{9029709.15} = 232.24$$

$$t^2 = \frac{232.24}{1.384} = 167.803 \text{ in.}$$

$$t = 12.9 \text{ in.}$$

24. *In attacking a post, or fortified position, in what manner should the fire from artillery be carried on?*

Previous to an assault, the artillery ought to support the other troops by a combined fire of guns, howitzers, and small mortars, so that, if possible, the fire may be simul-

taneous; as such a diversity of projectiles would tend to distract the defenders and prevent them from extinguishing any fire among buildings, besides throwing them into confusion at the moment of assault. In cases of surprise, when immediate action is required, the above method cannot, of course, be practicable.

25. *When firing guns of different calibres at long ranges, what are the probabilities of hitting the object?*

As the squares of the diameters of their respective shot, when of equal density, and fired with proportional charges.

PART XIV.

THE PARROTT RIFLE GUN.*

1. *Describe the Parrott rifle gun.*

This gun is made of cast iron reinforced at the seat of the charge with a wrought-iron jacket which is shrunk on.

2. *Name those now in use.*

10, 20 and 30–pdrs. army; 30 and 60–pdrs. navy; 100, 200 and 300–pdrs., the last three being the same for both army and navy.

3. *Name the smooth bore guns which correspond to these rifled guns in calibre.*

3–pdr. smooth bore to the 10–pdr.; 6–pdr. smooth bore to the 20–pdr; 9–pdr. smooth bore to the 30–pdr.; 32–pdr. smooth bore to the 100–pdr.; 8–inch to the 200–pdr.; 10–inch to the 300–pdr.

4. *What projectiles are used with these guns?*

Shells, case shot, solid shot, and canister.

* Although this gun is not a Regulation gun, yet in consequence of so many of them having been used in our service during the war of the late Rebellion, and being still in use, it is deemed necessary to devote a chapter to a description of it

WEIGHTS AND DIMENSIONS OF PARROTT GUNS.

	10-pdr.	20-pdr.	30-pdr.	30-pdr. Navy.	60-pdr. Navy.	100-pdr.	200-pdr.	300-pdr.
Weight in pounds...........	890	1750	4200	3550	5360	9700	16300	26500
Diameter of bore, in inches....	3.00	3.67	4.20	4.20	5.30	6.40	8.00	10.00
Length of bore, " ...	70.0	79.0	120.0	96.8	105.0	136.0	136.0	144.0

WEIGHTS OF PROJECTILES USED WITH PARROTT GUNS.

	10-pdr.	20-pdr.	30-pdr.	30-pdr. Navy.	60-pdr. Navy.	100-pdr.	200-pdr.	300-pdr.
	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.
Solid shot...	10.5	19.5	25 to 30	25 to 30	55	70 to 100	132 to 175	150 to 230
Shell........	9.75	18.75	......	... ..	......	......	....	....

5. *Give the number of grooves of these guns.*

10-pdr., 3 ; 20-pdr., 5 ; 30-pdr. Army and Navy, 7 ; 100-pdr., 9 ; 200-pdr., 11 ; 300-pdr. 15.

NOTE.—Depth of grooves in all is 1-10th inch. The twist is increasing.

6. *What kind of powder is employed?*

No. 7 or No. 5 powder for the 100, 200, and 300-pdrs.; and *mortar powder* for 10, 20, and 30-pdrs.

7. *What are the dimensions of the cartridges?*

The same as prescribed for ordinary cannon of the same bore.

8. *How are the guns loaded?*

The cartridge is first inserted and rammed home, and then the projectile, with the ring of brass at its rear end greased, if practicable. The fuze plug must, before firing, be screwed down firmly in its place. To insure its fitting closely, it is provided with a ring or washer of leather. The rammer should be hollowed out, to prevent injury to the fuze at the front end of the shell. When a round shot

is used, as for the ricochet, it should be wrapped in canvas, or other suitable material, in order to bring its centre as nearly in the axis of the bore as practicable.

NOTE.—With all rifle guns, sponges well saturated with oil should be used. A little grease, soft soap, or slush on the base of the projectile adds much to its certainty, and should be used when possible. The bores of the guns should be washed, and the grooves cleaned of all residuum and dirt after firing, and after the gun has cooled. Great care must be taken to send the projectile home in loading, in order that no space may be left between the projectile and cartridge. Before using shells, unless already loaded and fuzed, they must be carefully inspected both on their exterior and interior; and scrapers should be used to clear the cavity of all moulding sand before charging the shell. Special attention should be given to the insertion of the fuzes, and the threads of the fuze-hole should be carefully cleaned before screwing in the fuze. In all Parrott projectiles it should be carefully observed that the brass ring or cup is properly swedged, and that in case of the ring the cavities between it and the projectile are not clogged with dirt or sand.

In loading shells care should be taken to fill them entirely with powder, leaving no vacant space after the fuze is screwed in.

9. *Describe the sights.*

These consist of a fixed sight upon the right rim-base, and a brass movable sight, placed in a socket, which is screwed into the rear of the wrought-iron reinforce at the breech of the guns.

The movable sight is furnished with a sliding eye-piece, and is graduated up to 10°. The eye-piece is capable of lateral adjustment, to allow for the drift up to 10°, and for the effect of the wind.

10. *Are elevating screws employed with this gun?*

The 100-pdr., 200-pdr., and 300-pdr. and nearly all the 30-pdr. army guns, are provided with them. The first three (sea-coast) guns having no preponderance, can be fir[ed]

from fixed batteries without any elevating screws; but for close adjustment of the elevation in sighting, and for easy and rapid change of the position of the gun, the screw is highly important. It is so placed as to be managed by the person sighting the gun. At elevations above 20° it is better to detach the screw.

11. *What carriages are employed with these guns?*

For 10-pdr. army gun, the old 6-pdr. field carriage.
For 20-pdr. " " 12-pdr. "
For 30-pdr. " " 18-pdr. siege carriage.

For 100, 200, and 300-pdr. army guns, the carriages of the 8 and 10-inch smooth bores and a special iron carriage respectively.

12. *What charges of powder are used with these guns?*

300-pdr., 25 lbs.; 200-pdr., 16 lbs.; 100-pdr., 10 lbs.; 60-pdr. Navy, 6 lbs.; 30-pdr., $3\frac{1}{4}$ lbs.; 20-pdr., 2 lbs.; 10-pdr., 1 lb.

AVERAGE RANGES OBTAINED WITH PARROTT RIFLES ON MORRIS ISLAND.

[See General Gillmore's Report.]

Gun.	Projectile.	Charge.	Elevation.	Range.
	lbs.	lbs.	° ′	yds.
300-pdr.	250	26	13. 30	4290
200-pdr.	150	16	11. 47	4272
100-pdr.	70 to 100	10	13. 30	4272
300-pdr.	250	25½	5. 12	1950
200-pdr.	150	16	4. 12	1750
100-pdr.	70 to 100	10	4. 15	1750

In a trial of the 300-pdr. Parrott at West Point., N. Y., in March, 1863, with a charge of 25 lbs., weight of shell 252 lbs., and an elevation of $10\frac{5}{8}°$, the range was 2500 yards, the target being 600 feet above the level of the gun.

RANGES OF 100-PDR. PARROTT GUN.

Charge, 10 lbs. No. 7 Powder.

Elevation.	Projectile.	Range.	Time of flight.
°		yards.	
3¼	Long shell	1450	4½ seconds.
5	" "	2100	6½ "
5	Solid shot	2200	6½ "
10	Long shell	3520	13 "
10	Solid shot	3810	13 "
15	Long shell	4790	18 "
15	Solid shot	5030	18¼ "
15	Hollow shot	5190	19 "
20	Long shell	5853	21¾ "
20	Solid shot	6125	22½ "
20	Hollow shot	6338	23 "
25	Long shell	6820	28 "
25	Solid shot	6910	29 "
25	Hollow shot	7180	29½ "
30	Short shell	7810	32½ "
30	Hollow shot	7988	32¾ "
35	" "	8453	36¾ "

With No. 5 Powder, the ranges were slightly less at the lower angles; but at 30° and 35°, the ranges with the No. 5 and hollow shot were as follows:

At 30°	. . . .	8190 yards.
" 35°	. . . .	8845 "

Drift.

This is *to the right*, according to the rifling of the gun, and it is to be allowed for in sighting.

Though regular, under the same circumstances it is influenced by the force and direction of the wind. The following results have been obtained on trial:

Drift at 5°	. . . 4	yards.	
" 10°	. . . 10	"	
" 15°	. . . 48	"	wind from left.
" 20°	. . . 63	"	" "
" 25°	. . . 103	"	" " very fresh.
" 25°	. . . 43	"	" right, moderate.
" 30°	. . . 130	"	" left fresh.
" 35°	. . . 206	"	" " "

Greatest drift at 35°, 226 yards; least, 186 yards.

30-PDR. PARROTT SIEGE GUN.

Charge, 3¼ lbs. of Mortar Powder.

Elevation.	Projectile.	Range.	Time of flight.
°		yards.	
3¼	Shell, 29 lbs.	1500	4½ seconds.
5	" "	2200	6⅞ "
10	" "	3500	12¼ "
15	" "	4800	17⅝ "
20	" "	5700	21¼ "
25	" "	6700	27 "

A 30-pdr. Parrott gun mounted on Cumming's Point, Charleston Harbor, was used for 69 days and fired 4605 times bursting on the 4606th round; 4594 rounds were fired with 3¾ lbs. of powder, and percussion shells of 29 lbs., with an elevation of 40°. 237 rounds was the greatest number fired in any one 24 hours, and 2 rounds the least. The average per day was 127 rounds. During the first 2164 rounds the firing was at intervals of 5 minutes, but not continuous at this rate. The last 2442 rounds were fired at intervals of 15 minutes, not continuously, 157 rounds being the greatest number fired in one day and 7 the least, the daily average being 97 rounds.

20-PDR. PARROTT GUN.

Charge, 2 lbs. of Mortar Powder.

Elevation.	Projectile.	Range.	Time of flight.
°		yards.	
1	Case shot, 19½ lbs.	620	1⅞ seconds.
2	" " 19½ "	950	3⅛ "
3⅝	Shell, 18¾ "	1500	4¾ "
5	" 18¾ "	2100	6½ "
10	" 18¾ "	3350	11¼ "
15	" 18¾ "	4400	17¼ "

10-PDR. PARROTT GUN

Charge, 1 lb. of Mortar Powder.

Elevation.	Projectile.	Range.	Time of flight.
0		yards.	
1	Case shot, 10½ lbs.	600	
2	" " 10½ "	930	3 seconds.
2¾	Shell, 9¾ "	1100	3¼ "
3⅞	" 9¾ "	1460	4¾ "
4½	" 9¾ "	1680	5¾ "
5	" 9¾ "	2000	6½ "
6	" 9¾ "	2250	7¼ "
7	" 9¾ "	2600	8¼ "
10	" 9¾ "	3200	10¾ "
12	" 9¾ "	3600	12⅞ "
15	" 9¾ "	4200	16⅞ "
20	" 9¾ "	5000	21⅞ "

APPROXIMATE RULE FOR TIME OF FLIGHT.

Under 4000 yds., velocity of projectile, 300 yds. in 1 second.
" 6000 " " " 266 " " "
Over 6000 " " " 233 " " "

PENETRATION OF PARROTT RIFLE PROJECTILES INTO NEW PARAPETS.

[Colonel Haskins' Experiments.]

The target was a butt of new earth, 383 yards distant from the guns of Battery Cameron (Defences of Washington), from which the firing was made. [See Abbott's Report.]

Gun.	Projectile.	Weight of	Charge.	No. of shots	Penetration	Remarks.
		lbs.	lbs.		feet.	
100-pdr. parrott	Solid shot	98.5	10	2	18	
Do.	Do.	"	"	1	17	In new earth, 12 ft ; in natural bank, 5 feet.
Do.	Percussion shell	......	"	4	16	
Do.	Do.	......	"	1	11	Just reached natural bank.
30-pdr. Parrott.	Solid shot	30.5	3.5	4	12	
Do.	Percussion shell	27.5	"	1	12	
20-pdr. Parrott	Solid shot	19.5	2	6	10	
Do.	Percussion shell	18.75	2	2	9	
10-pdr. Parrott.	Unfilled shell	10.6	1	4	8	
Do.	Do.	"	1	1	5	In new earth, 3 ft. ; in natural bank 2 feet.

NOTE.—Some old 42-pdr. smooth-bore guns were rifled with the intention of using with them a Parrott projectile weighing 84 lbs., the idea being to use a rifle projectile of *double the weight* of the smooth bore shot.

PART XV.

MISCELLANEOUS.

1. *What is the velocity of sound in the air?*

At the temperature of 32° Fahrenheit, the velocity of of sound is about 1090 feet in a second. It is increased or diminished 1.07 feet for each degree of temperature above or below 32°. The velocity may be found by the following formula, taken from Lee's tables:

$$v = 1089\overset{ft.}{.}42 \sqrt{1 \times (t - 32°) \times 0.00208.}$$

in which t is the temperature in degrees of Fahrenheit's thermometer.

2. *How can the distance of an object be ascertained by the report of fire-arms?*

By observing the number of seconds that elapse between the flash and the report of a gun, and multiplying the number by the velocity of sound in the air.

3. *What is momentum?*

The force possessed by a body in motion; and is measured by the product of the mass of the body into its velocity.

4. *When equal masses are in motion, what proportion do their momenta bear to their velocities?*

They are proportional to their velocities.

5. *When the velocities are equal, what proportion do their momenta bear to their masses?*

They are proportional to their masses.

6. *What proportion do the momenta bear to each other when neither the masses nor velocities are equal?*

They are to each other as the products of their masses into their velocities respectively.

7. *What is the average weight of a horse?*

About 1000 pounds.

8. *What space does a horse occupy in the ranks; in the stalls; and at a picket?*

In the ranks a front of 40 in., a depth of 10 feet; in a stall, from 3½ to 4½ feet front; at picket, 3 feet by 9.

9. *What are the comparative effects of the labor of a man, and that of a horse or mule?*

Taking the usual effect of a man's daily labor as unity, a horse can carry a load on a horizontal plane, 4.8 to 6.1 times; and a mule, 7.6 times greater than a man. Taking a man with a wheelbarrow as unity, a horse in a four-wheel wagon can draw 17.5, and in a cart, 24.3; and a mule in a cart, 23.3 times greater burden.

On account of the peculiar build of a mule he is a superior pack animal to the horse.

10. *What load is allotted to an artillery horse?*

Light artillery horse, 700 lbs., including carriage.
Heavy field artillery horse. 800 lbs. "
Siege artillery horse, 1000 lbs. "

It is less than that drawn by a horse of commerce, in consequence of bad roads, bad forage, rapid movements, and forced marches.

11. *What weight can a team of four horses or more, draw with useful effect?*

Including the weight of carriage, 4 horses can draw 24 cwt., or 6 each; 6 horses, 30 cwt., 5 each; 8 horses, 36 cwt., 4½ each; and 12 horses, 48 cwt., or 4 each. It is

usual to estimate the weight of a carriage exceeding 12 cwt. as part of the load.

12. *What weights are carried by the riding, pack, and draught horses respectively?*

A horse carrying a soldier and his equipments (say 225 lbs.) travels 25 miles in a day (8 hours); a pack-horse can carry 250 to 300 lbs., 20 miles a day; and a draught-horse, 1600 lbs. 23 miles a day, weight of carriage included.

Usually a horse can draw 7 times as much as he can carry.

13. *What are the usual paces for horses in the artillery?*

Walk, trot and gallop; the last is seldom necessary.

14. *What is considered an ordinary day's march for mounted artillery, and rate of motion?*

An ordinary march is about 15 miles at 2½ miles per hour for 6 hours; this must depend upon the condition of the horses, state of the roads, and various other circumstances. Horses starting fresh, and resting after their work, may, on tolerable roads, perform 2 miles in half an hour; 4 miles in 1½ hours; 8 in 4, and 16 in 10 hours.

15. *What is the rate of march of horse artillery and cavalry?*

Walk 3¾ miles per hour, or 1 mile in 16 minutes; trot 7½ per hour, or 1 mile in 8 minutes; manœuvring gallop, at the rate of 11 miles per hour, or 1 mile in 5½ minutes; cavalry charge, 24 miles per hour, or at the rate of 1 mile in 2½ minutes.

16. *At what rate does infantry march?*

In common time, 90 steps=70 yards in 1 minute, or 2 miles 680 yards in an hour; in quick time, 110 steps=86 yards in one minute, or 2 miles 1613 yards in an hour; in double time 165 steps=151¼ yards in one minute, or 5 miles 275 yards in an hour.

17. *What space does a foot soldier occupy in the ranks, and what is his average weight?*

A front of 20 in., and a depth of 13 in., without the knapsack; the interval between the ranks is 13 in.; 5 men can stand in a space of 1 square yard. Average weight of men, 150 lbs. each.

18. *What is the daily allowance of water for a man?*

One gallon, for all purposes.

19. *What is it for a horse?*

Four gallons.

20. *What is the weight of a bushel of oats; or of wheat; of corn; and the weight of hay?*

32 lbs. to the bushel, or 25.71 lbs. to the cubic foot, in case of oats; 60 lbs. to the bushel, or 48.21 lbs. to the cubic foot in the case of wheat; 56 lbs. to the bushel, or 45.02 lbs. to the cubic foot, in case of corn; hay pressed in bundles, weighs 11 lbs. per cubic foot.

21. *What weight does an infantry soldier carry when in marching order?*

About 45 lbs. in all. His knapsack when packed weighs 24 lbs.; canteen when filled, and one day's provisions in haversack 5 lbs., rifle-musket, sling and bayonet, 10 lbs belts complete, including 40 rounds of ammunition, $6\frac{1}{4}$ lbs.

NOTE.—The maximum weight of the infantry equipment recently adopted, including three days' rations, is 58 lbs.; ordinarily it would be reduced to 20 or 25 lbs. In this new equipment a *clothing* bag takes the place of the knapsack.

22. *How is the area of a circle found?*

Square the diameter, and multiply by .7854 for the area; or square the circumference, and multiply by .07958 for the same result.

23. *How is the content of a conical frustum found?* *

Add into one sum, the areas of the two ends and the

mean proportional between them; take one-third of that sum for the mean area, and multiply it by the perpendicular height of the frustum, for its content.

24. *How is the mean proportional found for the above?*

By multiplying the areas of the two ends together and extracting the square-root of their product. A more simple rule is the following: As the diameter of the large end is to that of the small end, so is area of base to mean proportional required.

25. *How is the content of a spherical segment found?*

From three times the diameter of the sphere take double the height of the segment, then multiply the remainder by the square of the height, and this product by .5236; or, to three times the square of the radius of the segment's base add the square of its height, then multiply the sum by the height, and this product by .5236, for the content.

26. *How is the capacity or content of a Gomer chamber computed?*

This chamber being the frustum of a cone with a hemispherical bottom, its capacity will be found by applying the foregoing rules, viz.: first find the content of the frustum, then that of the spherical segment or bottom, and add their contents into one sum for the capacity.

27. *How is the content of a rectangular box ascertained?*

Multiply the length by the breadth, and this product by the depth.

28. *How is the capacity of a cylinder calculated?*

Multiply the area of the base by the height.

29. *How is the content of a barrel found?*

Multiply half the sum of the areas of the two interior circles, taken at the head and bung, by the interior length; or, to the area of the head add twice the area at the bung, multiply that sum by the length, and take one-third of the product for the content.

30. *What is meant by the term enfilade?*

Sweeping the whole extent of a work, line of troops, deck of a ship, &c., with shot or shells.

31. *What does defilade mean?*

The art of disposing guns, troops, or works in such a manner that they shall be protected from a plunging-fire from adjoining heights.

32. *What was the thickness required for an earthen parapet to resist the fire of field or siege guns of the old system?*

6 feet for **6**-pdrs.; 14 feet for **12**-pdrs.; **18** feet for **24** or **18**-pdrs.; four feet of oak or brick would resist cannon shot.

NOTE.—General Abbott [see Professional Papers, Corps of Engineers. No. 14] says that "in ordinary soils, parapets likely to receive a heavy fire from field artillery should not be less than 12 feet thick, of well rammed earth; to resist the fire of modern siege guns, this must be increased to 16 feet; to resist 7-inch and 8-inch rifled sea-coast guns, not less than 20 feet will suffice. All these dimensions must be increased when, as is generally the case, in the field, ramming is not attempted, and the fire is expected to begin before the earth has had time to settle."

33. *What thickness of ice will permit the passage of infantry, cavalry, and artillery?*

Ice 3 inches thick, will bear infantry marching in file; from 4½ to 6½ inches, cavalry and light artillery; and beyond that the heaviest gun carriages may pass in safety. Ice 8 inches thick will bear nearly 10 cwt. upon a square foot without danger.

34. *Give the limits to the depth of a ford for the passage of the different arms, and the most favorable bottom.*

A ford should not be deeper than 3 feet for infantry, 4 feet for cavalry, and 2½ feet for artillery. These limits must be lessened if the stream be swift.

A bottom of large stones is bad for cavalry and imprac-

ticable for carriages. Gravel is the best bottom. A sandy bottom, though good at first, is apt to deepen when many troops pass.

35. *How is the size of a rope designated?*

By its circumference: thus, a two-inch rope is a rope two inches in circumference.

36. *How is the strength of a hemp rope, or the weight it will support, ascertained?*

Square the circumference in inches, and divide by 6, for the weight in tons that it will bear suspended from it.

37. *How can the breadth of a river be ascertained without instruments?*

As follows:

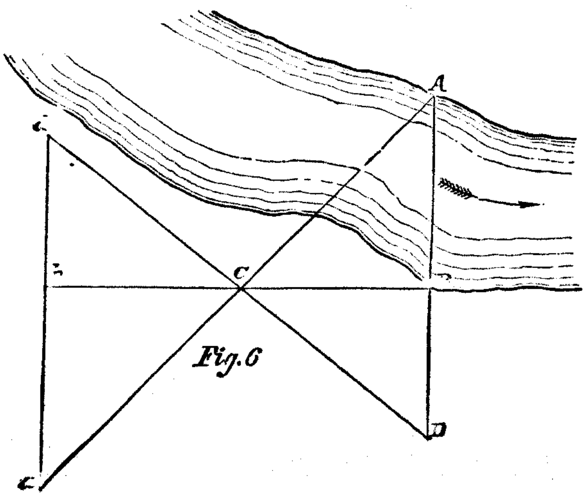

Fig. 6

1st. The line AB (the distance to be determined) is extended upon the bank to D, from which point, after having marked it, lay off equal distances CD and Cd; produce BC to b, making $Cb=CB$; then extend the line db until it intersects the prolongation of the line CA at a. The distance ab is equal to AB or the width of the river.

2d. Lay off any convenient distance, BC, perpendicular to AB, erect a perpendicular DC to AC, note the point D where it intersects AB produced; measure BD; then

$$AB=\frac{\overline{BC^2}}{BD.}$$

38. *How can the breadth of a river be ascertained by the means of the peak of a cap, or cocked hat?*

Place yourself at the edge of one bank and lower the peak of the cap, or point of the hat, till the edge cut the other bank, then steady your head, by placing your hand under your chin, and turn gently around to some level spot of ground on your own side of the river, and observe where your peak or, point of your hat again meets the ground; measure this distance, which will be nearly the breadth of the river.

39. *How do you ascertain the distance of an object by means of the tangent scale of a gun, the height of the object at the required distance being known?*

Direct the line of metal of the gun on the top of the object: then raise the tangent slide till the top of it and notch on the muzzle are in line with the foot of the object, and note what length of scale is required; then by similar triangles, as the length of the raised part of the tangent scale is to the length of the gun, so is the height of the distant object to the distance required.

40. *What composition may be used for greasing the ax*

Hog's lard softened by working it. If this cannot be procured, tallow or other grease may be used; if hard, it should be melted with fish-oil.

41. *What is the simplest method of bursting open strong gates?*

Explode a bag of gunpowder containing 50 or 60 lbs. suspended near the middle of the gate, upon a nail or gimlet, by means of a small piece of port-fire inserted at the bottom, and well secured with twine.

42. *What is the length of a pendulum to vibrate seconds, half and quarter seconds respectively?*

Seconds, 39.1 inches; half-seconds, 9.8 inches; and quarter-seconds, 2.45 inches.

43. *Give a formula for determining the length of the seconds pendulum in any latitude.*

$$l = \frac{1}{9.8696044}[32.1803 \text{ feet} - 0.0821 \cos.2 \text{ lat.}]$$

44. *How are the times of a single oscillation of two pendulums to each other?*

As the square-roots of their lengths.

45. *Repeat the table of measures.*

10 tenths	1 inch
4 inches	1 hand
12 inches	1 foot
28 inches	1 pace
3 feet	1 yard
2 yards	1 fathom
220 yards	1 furlong
1760 yards	1 mile

46. *Repeat the table of avoirdupois weight.*

27.34375 Troy grains	1 dram
16 drams	1 ounce
16 ounces	1 pound
25 pounds	1 quarter
4 qrs or 100 lbs	1 cwt
20 cwt	1 ton

NOTE.—In estimating weights in artillery, the English use 28 pounds to the quarter, 112 pounds to 1 cwt. and 2240 pounds to the ton.

47. *Repeat the table of Troy weight.*

24 Grains	1 Pennyweight
20 Pennyweights	1 ounce
12 ounces	1 pound

NOTE.—7,000 of Troy grains=1 avoirdupois pound,
5,760 " =1 pound Troy weight.
175 Troy pounds =144 avoirdupois pounds.
175 Troy ounces =192 " ounces.
437½ Troy grains =1 " ounce.
7,000 Troy grains to the pound are used in estimating weights in artillery,
Troy weight is named from Troyes, a town in France.

48. *What is the force of gravity?*

It is that force of attraction exerted by the earth upon all particles of matter, which tends to urge them towards its centre ; it is measured by the velocity *in feet* acquired in one *second* by a body falling in vacuo. The force of gravity in the latitude of 45°=32.17 feet per second being denoted by g, it may be found for any other latitude, l, by the formula :

$$g' = g\,(1-0.002588 \text{ cos. } 2\,l.)$$

The force of gravity at any height, h, being known, the force of gravity at the level of the sea will be determined by multiplying it by $1+\frac{5\,h}{4\,r}$ in which r, represents the radius of the earth.

49. *What is the specific gravity of a body?*

The ratio of the weight of a body to that of an equal volume of some other body assumed as a standard, usually pure distilled water at a certain temperature.

50. *What is the law of descent of falling bodies?*

The spaces fallen through from the commencement of the descent are proportional to the squares of the times elapsed.

51. *What compositions are made use of for preserving iron cannon?*

1.	Black lead, pulverized	12
	Red lead	12
	Litharge	5
	Lampblack	5
	Linseed Oil	66

Boil it gently about twenty minutes, during which time it must be constantly stirred.

2.	Umber, ground	3.75
	Gum Shellac, pulverized	3.75
	Ivory-black	3.75
	Litharge	3.75
	Linseed Oil	78
	Spirits of turpentine	7.25

The oil must be first boiled half an hour ; the mixture is then boiled 24 hours, poured off from the sediment, and put in jugs, corked.

3.	Coal tar (of good quality)	2 gals.
	Spirits of turpentine	1 pint

In applying lacker, the surface of the iron must be first cleaned with a scraper and a wire brush, if necessa-

ry, and the lacker applied hot, in two thin coats, with a paint brush. It is better to do it in summer. Old lacker should be removed with a scraper, or by scouring, and not by heating the guns or balls, by which the metal is injured.

About five gallons of lacker are required for 100 field-guns and 1000 shot; about 1 quart for a sea-coast gun. Before the lacker is applied, every particle of rust is removed from the gun, and the vent cleared out.

52. *How many gallons does a cubic foot contain?*

7.48 gallons.

53. *What is the weight of a gallon of distilled water?*

At the maximum density (39°.8 Fahr.), the barometer being at 30 inches, it weighs 8.33888 avoirdupois pounds, or 58373 Troy grains.

54. *What are the different lengths of plummets for regulating the march of infantry?*

Common time....	90 steps in a minute,	17.37 inches.
Quick time... ...	110 " " "	11.6 "
Double time......	165 " " "	5.17 "

55. *How is a plummet made?*

By means of a musket ball, suspended by a silk string, upon which the required lengths are marked; the length is measured from the point of suspension to the centre of the ball.

56. *Explain how to embark and disembark artillery and its stores.*

1. Divide the total quantity to be transported among the vessels, and place in each vessel every thing necessary for the service required at the moment of disembarkation, so that there will be no inconvenience should other vessels be delayed.

2. If a siege is to be undertaken, place in each vessel with each piece of artillery its implements, ammunition, and the carriages necessary to transport the whole or a part; the platforms, tools, instruments, and materials for constructing batteries; skids, rollers, scantling, and plank.

3. If a particular calibre of gun is necessary for any operation, do not place all of one kind in one vessel, to avoid being entirely deprived of them by any accident.

4. Dismount the carriages, wagons, and limbers, by taking off the wheels and boxes, and, if absolutely necessary, the axle-trees. Place in the boxes the linch-pins, washers, &c., with the tools required for putting the carriage together again. Number each carriage, and mark each detached article with the number of the carriage to which it belongs.

5. The contents of each box, barrel, or bundle, should be marked distinctly upon it. The boxes should be made small for the convenience of handling, and have rope handles to lift them by.

6. Place the heaviest articles below, beginning with the shot and shells (empty), then the guns, platforms, carriages, wagons, limbers, ammunition boxes, &c.; boxes of small arms and ammunition in the dryest and least exposed part of the vessel. Articles required to be disembarked first should be put in last, or so placed that they can be readily got at.

If the disembarkation is to be performed in front of the enemy, some of the field-pieces should be so placed that they can be disembarked immediately, with their carriages, implements, and ammunition; also the tools and materials for throwing up temporary intrenchments on landing.

7. Some vessels should be laden solely with such powder and ammunition as may not be required for the immediate service of the pieces.

8. On a smooth sandy beach, heavy pieces, &c., may be landed by rolling them overboard as soon as the boats ground, and hauling them up with sling-carts.

57. *Repeat table of measures of the metric system.*

10 millimeters	1 centimeter
10 centimeters	1 decimeter
10 decimeters	1 METER
10 METERS	1 decameter
10 decameters	1 hectometer
10 hectometers	1 kilometer
10 kilometers	1 myriameter

NOTE.—The length of the METER being known, the values of all the others are obtained by multiplying or dividing this length by 10.

58. *Give the table of equivalents in English measure.*

1 millimeter	=	0.039371 inches, nearly.
1 centimeter	=	0.39371 "
1 decimeter	=	3.937079 "
1 METER	=	39.37079 or = 3.280899 ft. = 1.093633 yds.
1 decameter	=	32 ft. 9.7 in.
1 hectometer	=	19 rd. 14 ft. 7 in.
1 kilometer	=	4 fur. 38 rd. 13 ft. 10 in. = 0.621383 miles.
1 myriameter	=	6 miles, 1 fur. 28 rd. 6 ft. 4 in.

59. *Repeat the table of weights of the metric system.*

10 milligrams	1 centigram
10 centigrams	1 decigram
10 decigrams	1 gram
10 grams	1 decagram

10 decagrams	1 hectogram
10 hectograms	1 kilogram
10 kilograms	1 myriagram
10 myriagrams	1 quintal
10 quintals	1 millier or tonneau

60. *Give the equivalent in Avoirdupois and Troy weight.*

1 milligram	=	0.01543316	grains,	Troy.	
1 centigram	=	0.1543316	"	"	
1 decigram	=	1.543316	"	"	
1 gram	=	15.433159	"	"	=.03528 oz. avoirdupois
1 decagram	=	.3528	ounces,	avoirdupois	
1 hectogram	=	3.528	"	"	
1 kilogram	=	2.204737	pounds	"	
1 myriagram	=	22.04737	"	"	
1 quintal	=	220.4737	"	"	
1 millier or ton.	=	2204.737	"	"	

APPENDIX, NO. 1.

TABLES OF AMERICAN AND FOREIGN CANNON AND AMMUNITION.

TABLE 1.

UNITED STATES ARMY CANNON AND AMMUNITION.

KIND OF CANNON.	MATERIAL.	WEIGHT.	PREPONDERANCE.	EXTREME LENGTH.	MAX. DIAMETER.	MIN. DIAMETER.	LENGTH OF BORE IN CALIBRES.	NUMBER OF GROOVES.	WIDTH OF GROOVES.	WIDTH OF LANDS.	DEPTH OF GROVES.	TWIST	WINDAGE.	CHARGE.		PROJECTILES.				REMARKS.
														MAXIMUM.	REGULATION	SOLID SHOT.	SHELLS, EMPTY.	INITIAL VELOCITY, FT. PER SEC'D.	RANGE.	
SEA-COAST PIECES.		lbs.	lbs.	in.	in.	in.			in.	in.	in.		in.	lbs.	lbs.	lbs.	lbs.	ft.	yds.	The bore of all cannon of *late models*, those constructed since 1860, is cylindrical, terminating at bottom in a semi-ellipsoid.
GUNS.																				
20-in. S. B.	Cast Iron.	116000	None	243.50	64.0	34.3	10.50	....	....	....	....	....	.13	200	100	1080.0	....	....	....	All cannon in this Table except the Gatling gun, are muzzle-loading.
15-in. "	"	49000	"	190.00	48.0	25.0	11.00	....	....	....	....	....	.13	100	50	450.0	330.00	1534	7732 at 32°	"Mammoth Powder" is employed for the 20, 15, and 13-inch guns.
13-in. "	"	37000	"	177.60	41.6	21.0	12.00	....	....	....	....	....	.13	....	30	283.0	216.00	....	....	
10-in. "	"	15000	"	136.60	32.0	16.2	10.50	....	....	....	....	....	.13	25	*15 & 18	128.0	101.75	*1275	*3976 at 20°	These 10-inch guns will probably be converted into 8-in. rifled cannon by inserting an inner tube of steel or wrought iron, after the plan of Palliser and Parsons in England.
12-in. rifled	"	52000	"	192.00	48.0	25.0	14.00	21	1.045	.75	.090	Uniform, 1 turn in 60, 70 & 80 ft.	.08	....	....	620.0	475.00	....	....	
10-in. "	"	40681	"	180.00	41.6	21.0	15.85	17	1.150	.70	.090	Uniform, 1 turn in 50 ft.	.08	....	....	292.0	....	....	....	
MORTARS.																				
15-in. S. B.	"	....	"	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	None of these mortars have been constructed.
13-in. "	"	17120	"	54.05	....	....	2.7	Semi-axis of ellipsoid (bottom of bore) = 9 inches.					.13	20 lbs. to 7 lbs.		....	200.00	....	4325 to 2190	
10-in. "	"	7300	"	47.05	....	....	3.25	do. do. do.					.13	12 lbs. to 2½ lbs.		....	*104.00	....	4536 to 3471	* Old Columbiad Shell filled with sand.
HOWITZERS.																				
24-pdr. Flank Defence, S. B. = 5.8 in.	"	1476	70	69.00	....	....	9.15	Diameter of Chamber (Cylinder) 4.62 inches, and length of Chamber 4.75 inches.					.14	2	2	....	16.08	....	1322 at 5°	This howitzer no longer belongs to the system, but is still employed in many of our Forts on the Sea-Board for the defence of the ditches.
SIEGE PIECES.																				
GUNS.																				
4½-in. rifled	"	3570	300	133.00	15.6	9.0	26.5	9	.97	0.6	.075	Uniform, 1 turn in 15 ft.	.05	*3¼	*3¼	32.5	25.05	1280	3556 at 10°	* "Mortar Powder."
MORTARS.																				
10-in. S. B.	"	1900	None	28.00	....	....	2.05	Semi-axis of ellipsoid (bottom of bore) = 7.5 inches.					.13	4 lbs. to 8 oz.		....	90.00	....	2064 to 189	
8-in. "	"	1010	"	22.00	....	....	2.00	Semi-axis of ellipsoid (bottom of bore) = 6 inches.					.12	2¼ lbs. to 8 oz.		....	46.00	....	1275 to 360	
24-pdr. Coehorn S. B. = 5.8 in.	Bronze	164	....	16.32	....	....	1.51 exclusive of chamber.	Diameter of Chamber (Gomer) 3 x 2 inches, and length of Chamber 4.25 inches.					.14	8 oz. to 5 oz.		....	16.8	....	1200 to 25	
HOWITZERS.																				
8-in. S. B.	Cast Iron.	2600	380	60.00	....	....	5.81	....	....	....	....	....	.12	4	....	....	45.00 / 62.00*	....	2280 at 12½°	* Case Shot, filled.
FIELD PIECES.																				
GUNS.																				
12-pdr. S. B.	Bronze	1227	105	72.15	13.0	8.5	13.75	....	....	....	....	....	.10	2.5	....	12.3	‡8.34 / †12.17 / §15.0	1495	1992 at 10°	‡ Shell, † Case Shot. § Finished Canister.
3½-in. rifled	Wro'ght Iron.	1156	None.	73.84	....	....	21.50	7	....	....	.075	Uniform, 1 turn in 12 ft.	.05	....	....	....	....	....	....	No guns of this calibre have been constructed.
3-in. "	"	820	40	72.70	9.4	6.0	21.50	7	.84	0.5	.075	Uniform, 1 turn in 10 ft.	.05	1.0	....	10.0	9.5	....	3972 at 30°	
Gatling No. 1, rifled = 1 inch, B. L.	Steel.	1008	110	68.00	....	....	33.00	6	....	....	.010	Uniform, 1 turn in 6 ft.	....	.75 oz	....	8 oz.	*9½ oz.	....	1200 & *200	* Canister, 15 bullets, each .48 in. diameter.
Gatling No. 2, rifled = ½ inch, B. L.	"	365	45	60.00	....	....	64.00	6	....	....	.010	Uniform, 1 turn in 42 inches.	....	70 grs	....	450 grs.	....	....	900 at 2° 25′	
Gatling No. 3, rifled = .45 inch, B. L.	"	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	To replace the 1-inch and 0.5-inch guns
HOWITZER.																				
12-pdr. Mountain, S. B. = 4.6 inches.	Bronze	220	30	37.21	....	....	6.10 exclusive of chamber.	Diameter of Chamber (Cylinder) = 3.34 inches, and length = 2.75 inches.					.10	.05	....	....	† 8.34 / ‡12.17	....	1005 at 5°	† Shell. ‡ Canister.

RIFLED CANNON CONSTRUCTED BY MR. PARROTT, OF COLD SPRING, N. Y. USED EXTENSIVELY IN THE UNITED STATES ARMY AND NAVY.

KIND OF GUN.	Nature of Service.	Weight.	Length of Bore.	Rifling. Number of Grooves.	Rifling. Depth of Grooves.	Rifling. Twist.	Charge.	Projectile. Solid Shot.	Projectile. Shell.	Range.	Elevation.
		lbs.	in.		in.		lbs.	lbs.		yds.	° ′
300 pdr. (10 in.)	Army & Navy	26000	144	15	.10	Increasing.	25	250	......	4290	13.30
200 " (3 in.)	do.	16300	136	11	.10		16	132 to 175	....	4272	1.47
100 " (6.4 in.)	do.	9700	130	9	.10		10	70 to 100	80 and 101	1750	4.15
60 " (5.3 in)	Navy.	5360	105	7	.10		6	55	......	......	......
30 " (4.2 in.)	do.	3550	96.8	7	.10		3¾	25 to 30	......	......	......
30 " (4.2 in.)	Army.	4200	120	7	.10		3¾	do.	29.0	6700	25.0
20 " (3.67 in.)	do.	1750	79	5	.10		2	19.5	18.75	4400	15.0
10 " (3 in.)	do.	890	70	3	.10		1	10.5	9.75	5000	20.0

REMARKS.—The Parrott cannon are all muzzle loa[illegible]ng. They are all made of cast iron, reinforced at the seat of the charge, with a wrought-iron jacket which is shrunk on. The three heavier [illegible] have no preponderance.

TABLE 3.

BRITISH CANNON AND AMMUNITION.

MAKER AND KIND OF GUN.	NATURE OF SERVICE.	MATERIAL.	WEIGHT.	PREPONDERANCE.	LENGTH.	LENGTH OF CHAMBER.	LENGTH OF BORE.	NUMBER OF GROOVES.	WIDTH OF GROOVES.	DEPTH OF GROOVES.	SYSTEM EMPLOY'D.	TWIST IN CALIBRES.	CHARGE. BATTERING.	CHARGE. SERVICE.	PROJECTILES. PALLISER SOLID SHOT.	PROJECTILES. BOXER SHRAPNELL.	PROJECTILES. CASE SHOT.	INITIAL VELOCITY IN FEET.	REMARKS.
					in.	in.	in.		in.	in.			lb.	lb.	lb.	lb.	lb.		
ROYAL ARSENAL, WOOLWICH.																			S. S. Sea Service. L. S. Land Service. M. L. Muzzle loader. B. L. Breach loader. Upper numbers under head of "Charge" refer to "Pebble Powder," and lower numbers to "Rifle Large Grain Powder." Where two initial velocities are given to one calibre they were obtained with Pebble and Rifle large grain, battering charges, respectively. 9, 10, 11 and 12-inch calibres have all steel tubes. One 7-ton and one 6.5-ton gun has a wrought iron tube.
12-in. No. 1, M. L.…	S. S.	Wro'ght Iron.	35 tons.	3 cwt.…	191.75	18.0	162.5	9	1.5	0.2	Woolwich.	Increasing from 0 to 1 in 35.	110	....	600	497	230	......	
12-in. No. 2, " …	L. S. & S. S.	"	25 "	3 "…	171.50	18.0	145.0	9	1.5	0.2	"	1 in 100 to 1 in 50 at muzzle.	85 67	55 50	600	......	......	1180 1300	
11-in. " …	L. S.	"	25 "	3 "…	170.00	26.0	145.0	9	1.5	0.2	"	0 to 1 in 35	85 70	60 50	530	......	......	1315	
10-in. " …	L. S. & S. S.	"	18 "	3 "…	170.00	27.5	145.0	7	1.5	0.2	"	From 1 in 100 to 1 in 40.	70 60	44 40	400	384	130	1298 1364	
9-in. No. 1, " …	"	"	12 "	None.	147.00	17.5	125.0	6	1.5	0.18	"	0 to 1 in 45	50 43	 30	250	251.5	189.5	1336 1420	
" " 2, " …	"	"	12 "	5 cwt.…	147.00	21.0	125.0	6	1.5	0.18	"	"	50 43	 30	250	......	96.4	1336 1420	
" " 3, " …	"	"	12 "	5 "…	147.00	21.0	125.0	6	1.5	0.18	"	"	50 43	 30	250	......	96.4	1336 1420	
" " 4, " …	"	"	12 "	5 "…	147.00	21.0	125.0	6	1.5	0.18	"	"	50 43	 30	250	......	100.0	1420	
8-in. " 1, " …	S. S.	"	9 "	None.	136.5	16.0	118.0	4	1.5	0.18	"	0 to 1 in 40	35 30	 20	180	175.25	68.0	......	
" " 2, " …	"	"	9 "	4 cwt.…	136.5	18.5	118.0	4	1.5	0.18	"	"	35 30	 20	180	......	......	1363 1413	
" Howitzer, " …	L. S.	"	46 cwt.	2 "…	61.0	2.5	48.0	4	1.5	0.18	"	1 in 16	......	......	......	......	......	......	
7-in. No. 1, " …	"	"	7 tons.	4½ "…	142.8	13.5	126.0	3	1.5	0.18	"	1 in 35	30 22	 14	115	......	102.0	......	
" " 2, " …	"	"	7 "	3 "…	141.5	15.5	126.0	3	1.5	0.18	"	[illegible]	[illegible] 22	 14	115	112	67.0	1458	
" " 3, " …	S. S.	"	6.5 "	5½ "…	125.25	13.5	111.0	3	1.5	0.18	"	"	30 22	 14	115	......	67	......	
" " 4, " …	"	"	6.5 "	3 "…	126.00	15.5	111.0	3	1.5	0.18	"	"	30 22	 14	115	113	67	1430 1525	
" " 5, " …	"	"	4.5 "	5 "…	124.00	15.5	111.0	3	1.5	0.18	"	"	30 22	 14	115	......	67	......	
64-pdr. No. 1 (6.3 in.), M. L.	L. S. & S. S.	"	64 cwt.	7 "…	111.0	7.5	98.0	3	.6 & .4	.11 & .08	Shunt.	1 in 40.	.....	8	......	......	......	1017	Initial velocity with common shell, weight 57 lbs. 9 oz.; bursting charge 7 lb. Total weight, 64 lb. 9 oz.
64-pdr. No. 2 (6.3 in.), M. L.	"	"	64 "	3 "…	113.0	7.5	98.0	3	.6 & .4	.11 & .08	"	"	.....	8	......	......	......	1170	
64-pdr. No. 3 (6.3 in.), M. L.	"	"	64 "	3¾ "…	111.5	7.0	97.5	3	.6 & .4	.11 & .08	"	"	.....	8	......	......	......	1170	
16-pdr. (3.6 in.), M. L.	L. S.	"	12 "	10 lbs.…	74.45	10.36	68.4	3	.8	.11	French, modified	1 in 30	.....	3	......	......	......	1380	Fired with common shell, weight 14 lbs. 13 oz.; bursting charge, 1 lb. Total weight, 15 lb. 13 oz.
9-pdr. No. 1 (3-in.), M. L.	"	"	8 "	7 "…	68.50	3.7	63.5	3	.8	.11	"	"	.....	1.75	Fired with common shell, weight 8lb. 8oz.; bursting charge, 8oz.			1380	*Note*—In addition to the muzzle-loading guns there are the following *breech-loaders*: 2 varieties of 7-in. guns; 2 of 40-pdrs.; 3 of 20-pdrs.; one 12-pdr.; one 9-pdr., and one 6-pdr.
9-pdr. No. 2 (3-in.), M. L.	S. S.	"	6 "	3 "…	58.0	3.7	53.0	3	.8	.11	"	"	.....	1.50	Fired with common shell, weight 8lb. 8oz.; bursting charge, 8 oz.			1234	
9-pdr. (3-in.), M. L.	Indian Service.	Bronze.	8 "	8 "…	67.0	3.7	63.5	3	.8	.11	"	"	.....	1.50	Fired with common shell and Boxer shrapnell, 9.25 lbs., and case shot 6 lb. 12 oz.			......	
7-pdr. No. 1 (3-in.), M. L.	Mountain Gun.	Steel.	150 lbs.	3 to 5 lbs.	26.5	2.0	24.0	3	.6	.1	French.	1 in 20	.....	6 oz. F.G.	Fired with common shell, 6 lb. 14 oz.; Boxer shrapnell, 7 lb. 5 oz., and case shot 6 lb. 14 oz.			673	
" No. 2 (3-in.), M. L.	Boat Gun.	Bronze.	200 "	45 lbs.…	36.0	3.0	32.15	3	.6	1	"	"	.....	8 oz. F.G.	Fired with common shell, 6 lb. 14 oz.; Boxer shrapnell, 7 lb. 5 oz., and case shot 6 lb. 14 oz.			......	
64-pdr., converted from 32-pdr. smooth bore M.L. (6.29 in.	L. S.	Cast iron, with Wrought iron tube.	58 cwt. & 56 "	......	114.0	7.0	108.45	3	1.3	.145	Woolwich.	1 in 40	.....	8	Common shell, 57 lbs. 9 oz.; bursting charge, 7 lbs.—Total, 64 lbs. 9 oz.			......	Palliser converted cast-iron guns bored out, and wrought iron coiled (A) tube with (B) tube shrunk on at breech end; carefully fitted into enlarged bore of cast-iron gun, and prevented from shifting by a pin.
64-pdr. converted from 8-in. smooth bore M.L. (6.29in.)	L. S. & S. S.	"	71 cwt.	......	108.0	7.0	103.27	3	.73	.115	"	"	.....	8	Common shell, 57 lbs. 9 oz.; bursting charge, 7 lbs.—Total 64 lbs. 9 oz.			......	
80-pdr., converted from 68-pdr. smooth bore M. L. (6.29 in.)	L. S.	"	5 tons.	......	120.0	7.0	113.26	3	1.3	.145	"	"	.....	10	Common shell, 71 lbs. 14 oz.; bursting charge, 8 lbs. 2 oz.—Total 80 lbs.			......	
SIR WM. ARMSTRONG.																			
12-in. No. 1, M. L. …	L. S.	Wro'ght iron	38 "	......	225.0	24.5	200.00	9	1.5	.2	"	0 to 1 in 35	......	......	699⅞	†617.5	......	......	† Including bursting charge 1 lb. 15 oz. *Note.*—"Pebble Powder" is large grain powder, irregular in shape and similar to the Rodman "Mammoth Powder."
" " 2, " …	S. S.	"	35 "	1½ cwt.…	191.75	27.5	162.5	9	1.5	.2	"	"	110	85	699⅞	†617.5	......	1300	
" " 3, " …	L. S. & S. S.	"	25 "	6 "…	161.5	18.0	145.0	9	1.5	.2	"	1 in 100 to 1 in 50.	85 67	55 50	600	†497 1/16	......	1300 1180	
11-in. … " …	L. S.	"	25 "	1½ "…	170.0	26.0	145.0	9	1.5	.2	"	0 to 1 in 35	85 70	60 50	536 7/16	......	200.0	1315 1247	
10-in. … " …	L. S. & S. S.	"	18 "	1 cwt. 18 lbs.	170.75	27.5	145.5	7	1.5	.2	"	1 in 100 to 1 in 40.	70 60	44 40	400 6/16	404 9/16	143.0	1364 1298	
9-in. … " …	"	"	12 "	3 cwt.…	147.0	21.0	125.0	6	1.5	.318	"	0 to 1 in 45	50 43	30 30	250	255 5/16	100.0	1420 1336	
8-in. … " …	S. S.	"	9 "	3¾ ct. 16 lbs.	136.5	18.5	118.0	4	1.5	.318	"	0 to 1 in 40	35 30	20 20	180	180	68.0	1413 1330	
7-in. No. 1, " …	L. S.	"	7 "	2¾ ct. 2 lbs.	141.5	15.5	126.0	3	1.5	.318	"	1 in 35	30 22	14 14	115	116 8/16	67	1561 1458	For these three calibres double shells weighing 146 lb. 12 oz. with bursting charge of 13 lb. 3 oz. are also employed.
" " 2, " …	S. S.	"	6 tons, 10 cwt.	3¾ cwt.…	126.0	15.5	111.0	3	1.5	.318	"	"	30 22	 14	115	116 6/16	......	1525 1430	
" " 3, " …	"	"	90 cwt.	2½ ct. 5 lbs.	124.0	15.5	111.0	3	1.5	.318	"	"	30 22	 14	115	116 8/16	......	......	
64-pdr. (6.3 in.) " …	L. S. & S. S.	"	64 "	2½ ct. 18 lbs.	111.5	7.0	97.5	3	.73	.115	Plain groove	1 in 40	.....	8	77 1/16	66 8/16	51.0	1252	
40-pdr. (4.75 in.) " …	L. S.	"	35 "	28 lbs …	96.0	14.0	85.5	3	.8	.1	Woolwich.	1 in 35	8	7	......	39 6/16	......	1357 1336	
25-pdr. (4-in.) " …	"	"	18 "	Ab't 10 lbs.	94.5	10.0	88.0	3	......	......	"	"	.....	.....	......	......	......	......	
16-pdr. (3.6 in.) " …	"	"	12 "	10 lbs.…	72.45	9.36	68.4	3	.8	.11	French, modified	1 in 30	3	3	Common shell, 14 lb. 13 oz.; bursting charge 1lb.—Tot'l 15lb. 13 oz.			1352	
9-pdr. No. 1 (3-in.), M. L.	L. S. & S. S.	"	8 "	7 "…	68.50	3.9	63.5	3	.8	.11	"	"	.....	1¾	Common shell, 8 lb. 8 oz.; bursting charge 8 oz.—Total 9 lbs. Boxer shrapnell, 9 lb. 4 oz.; bursting charge, ¾ oz.			1380	
" No. 2 (3 in.), M. L.	S. S.	"	6 "	29½ lbs.…	58.00	3.7	53.0	3	.8	.11	"	"	13¼	1½	Common shell, 8 lb. 8 oz.; bursting charge, 8 oz.—Total 9 lbs. Boxer shrapnell, 9 lb. 4 oz.; bursting charge ¾ oz.			1262	
" No. 3 (3-in.), M. L.	L. S.	"	6 "	10 "…	71.00	3.7	66.0	3	.8	.11	"	"	......	......	......	......	......	......	
7-pdr. No. 1 (3-in.), M. L.	"	Steel.	150 lbs.	3 "…	26.5	2.0	24.0	3	.6	.114	French.	1 in 20	.....	½	......	......	......	673	
" No. 2 (3-in.), M. L.	L. S. & S. S.	"	200 "	5 "…	38.90	2.0	36.0	3	.6	.114	"	"	.....	¾ F.G.	Common shell, 6 lb. 14 oz.; bursting charge, 7 oz.—Boxer shrapnell, 7 lb. 5 oz., bursting charge ½ oz.—Total 7 lb. 5½ oz.			955	This gun has also a double shell of 11 lbs.—bursting charge, 1 lb
10-in. M. L. …	L. S.	Wro'ght iron	6 tons.	None.	77.25	......	60.0	7	......	......	Woolwich.	1 in 13	......	......				......	

MAKER AND KIND OF GUN.	NATURE OF SERVICE.	MATERIAL.	WEIGHT.	PREPONDERANCE.	LENGTH.	LENGTH OF CHAMBER.	LENGTH OF BORE.	NUMBER OF GROOVES.	WIDTH OF GROOVES.	DEPTH OF GROOVES.	SYSTEM EMPLOY'D.	TWIST IN CALIBRES.	CHARGE. BATTERING.	CHARGE. SERVICE.	SEGMENT SHELL. COMMON SHELL. WEIGHT	SEGMENT SHELL. COMMON SHELL. B.CH'GE	SEGMENT SHELL. WEIGHT EMPTY. lb. oz.	SEGMENT SHELL. BURST'G CHARGE. lb. oz. grs.	INITIAL VELOCITY IN FEET.	REMARKS.
8-in. Howitzer, M. L.	"	"	46 cwt.	2 cwt.…	61.125	12.5	48.0	4	1.5	.18	"	1 in 16	.....	10.5	......	......	......	......	......	8-in. howitzer, fires a common shell, weight empty, 167 lbs.; bursting charge, 14 lbs. 9 oz.
7-in. No. 1, B. L. Screw.	L. S. & S. S.	"	82 "	6 ct. 100 lbs.	120.0	16.375	99.5	76	.166	.06	Poly groove	1 in 37	.....	11	83 98	6½ 7 10/16	98 9½	3 2 0	1165	
" No. 2, B. L., Screw.	L. S.	"	72 "	8 cwt.…	118.0	14.625	97.5	76	.166	.06	"	"	.....	10	98	7 10/16	98 9½	3 2 0	1013	
40-pdr. No. 1 (4.75 in.), Screw.	L. S. & S. S.	"	35 "	5 cwt. 47 lbs.	120.0	13.875	106.37	56	.166	.06	"	1 in 36½	.....	5	37 14/16	2¼	38 9½	0 13 0	1180	Boxer shrapnell, 39 lbs.; bursting charge 3 oz.
" No. 2 (4.75 in.), Screw.	"	"	32 "	4¾ cwt.…	120.0	13.875	106.37	56	.166	.06	"	"	.....	5	37 14/16	2¼	38 9½	0 13 0	......	" " "
20-pdr. No. 1 (3.75 in.), Screw.	L. S.	"	16 "	2 cwt. 11 lbs.	96.0	12.375	84.0	44	.166	.06	"	1 in 38	.....	2½	20½	1⅛	19 10½	0 0 700	1130	Case shot, 15 lb. 12 oz.
" No. 2 (3.75 in.), Screw.	S. S.	"	15 "	1½ cwt.…	66.125	11.375	54.125	44	.166	.06	"	"	.....	2½	20½	1⅛	19 10½	0 0 700	......	
" No. 3 (3.75 in.), Screw.	"	"	13 "	1 cwt. 52 lbs.	66.125	11.375	54.125	44	.166	.06	"	"	.....	2½	20½	1⅛	19 10½	0 0 700	1000	
12-pdr. (3-in.), Screw…	L. S. & S. S.	"	8 "	1¾ ct. 3 lbs.	72.00	8.875	61.375	38	.148	.045	"	"	.....	1½	10¾	½	10 6½	0 0 558	1150	Boxer shrapnell, 10 lb. 11 oz.; bursting charge, ¾ oz., and case shot 11 lb. 8 oz.
9-pdr. (3-in.), " …	"	"	6 "	82 lbs.…	62.00	7.0	52.5	38	.148	.045	"	"	.....	1⅛	8⅛	6/16	8 3⅜	0 0 300	1057	Boxer shrapnell, 8 lb. 11 oz.; bursting charge ¾ oz.; case shot 9 lb.
6-pdr. (2.5 in.) " …	"	"	3 "	55 "…	60.125	7.375	53.0	32	.148	.045	"	1 in 30	.....	¾	......	......	5 7	0 0 200	1046	Case shot 6 lbs.
64-pdr. (6.4 in.) B.L., Wedge.	L. S.	"	64 "	5½ cwt.…	110.0	14.875	92.0	70	.166	.06	"	1 in 40	.....	9	60	4½	......	......	......	Boxer shrapnell 65 lb. 14 oz.; bursting charge 5 oz.
40-pdr. (4.75 in.) B.L., Wedge.	S. S.	"	32 "	2¾ ct. 5 lbs.	98.0	13.875	83.5	56	.166	.06	"	1 in 36½	.....	5	37⅞	2¼	38 9½	0 13 0	......	Boxer shrapnell 39 lbs.; bursting charge 3 oz.
Gatling gun No. 1 (0.45 in.), B.L.	L. S.	"	3 cwt. 84 lbs	......	32.0	3.156	31.95	7	......	......	Martini-Henry.	......	.....	85 gr. R.F.G.	......	......	......	......	......	
Gatling gun No. 2 (0.65 in.), B.L.	S. S.	"	7 " 35 "	......	62.5	4.855	33.0	7	......	......	"	......	......	......	......	......	......	......	......	
80-pdr. conv'ted from 68-pdr. (6.29 in.), M. L.	L. S.	Cast iron, with W. I. (A) tube.	5 tons.	1¾ ct. 4 lbs.	120.0	7.0	113.25	3	......	......	Woolwich.	1 in 40	.....	10	71¼	8¾	......	......	1240	Has an inner band of coiled wrought iron. Boxer shrapnell 77 lbs. 6 oz.; bursting charge 6 oz.
64-pdr. conv'ted from 8-in. (6.29 in), M.L.	S. S.	"	71 cwt.	6 cwt. 42 lbs.	108.0	7.0	103.27	3	......	......	Plain groove	"	.....	8	57½	7.0	......	......	1230	Boxer shrapnell 65 lbs. 10 oz.; bursting charge 9 oz.
64-pdr. conv'ted from 32-pdr. (6.29 in.), M. L.	L. S.	"	53 "	6 cwt.…	114.0	7.0	108.45	3	......	......	"	"	.....	8	57½ 57½	7.0 7.0	......	......	 1245	" " "

TABLE 4.

BRITISH CANNON:—ADDITIONAL DETAILS.

KIND OF GUN.	GREATEST NUMBER OF ROUNDS FIRED WITHOUT INJURY TO GUN.	MAXIMUM RANGE RECORDED.	CHARGE OF POWDER.	WEIGHT OF PROJECTILE.	ELEVATION.	REMARKS.
		yds.	lb. oz.	lb.	° ′	
12-in. 35 tons...	152	4800	110.0	700	9.0	
12 " {23 " / 25 "}	460	3761	67.0	592	9.5	
11 " 25 " ..	25[illegible]	3694	85.0	535	7.5	
10 " 18 " ..	726	4266	60.0	400	10.0	
9 " 12 " .	1222	9920	43.0	250	33.2	
8 " 9 " ..	682	3662	30.0	184	16.33	
7 " 7 " ..	2332	7114	22.0	115	18 18	
64-pdr. 64 cwt.	1681 *	4000	8.0	64	11.30	* Two of these calibres have been tested to destruction; one broken into 38 pieces after 2270 rounds, the other burst at 2211 rounds.
16 " 12 " .	1350	4000	3.0	16	11 0	
9 " 8 " .	630	3500	1.12	9	11.0	
Converted 80-pdr. 5 tons.	189	3500	10.0	80	9.44	

TABLE 5.

CANNON CONSTRUCTED BY MESSRS. J. VAVASSEUR, LONDON.

KIND OF GUN.	MATERIAL.	BREECH OR MUZZLE LOADING.	CALIBRE.	LENGTH OF BORE.	TOTAL WEIGHT.	CHARGE.	NATURE OF PROJECTILE.	WEIGHT OF PROJECTILE.	INITIAL VELOCITY.	TOTAL ENERGY IN FOOT TONS.	ENERGY PER INCH OF CIRCUMFERENCE OF PROJECTILE IN FOOT TONS.	ENERGY PER LB. OF POWDER IN CHARGE, FOOT TONS.	REMARKS.
			in.	in.				lb.					
12-inch....	Steel	Muzzle....	12	187	27 tons.....	120 lbs...	Armor piercing.......	600	......	......	......	......	All these cannon are rifled with three ribs projecting inwards; each rib being bounded by two faces converging to the centre of the bore, and one inner face concentric with the bore; the corners are rounded off with curves of very small radius. The width of rib is in direct proportion to the calibre; in the 12-in. gun it is 1.5 in., while the depth varies from 0.3 in. in the 12-inch gun to 0.15 in. in the 2.5-in. gun. The projectiles for these guns are grooved, thus giving them a fair bearing on the ribs for the cylindrical part of the projectile.
9 "	"	"	9	144	10 "	50 " ..	"	250	......	......	......	......	
7 "	"	"	7	126	5 " 1 cwt.	30 " 22 " 14 "	"	115	1561 1412 1218	1943 1589 1183	89.5 73.1 54.4	64.8 72.2 84.5	
100-pdr....	"	"	6.3	111	80 cwt,.....	20 " 18 " 12 "	"	100	1440 1400 1223	1407 1359 1024	73.6 69.0 52.4	71.9 75.5 85.3	
80 "	"	"	6.0	108	64 "	16 " ..	"	80	......	......	......	......	
60 "	"	"	5.5	101	48 "	12 " ..	"	60	......	......	......	......	
40 "	"	"	4.75	96	30 "	8 " ..	Solid shot or common shell.....	40	......	......	......	......	
20 "	"	"	3.75	67	12 "	3 " ..	"	20	......	......	......	......	
9 "	"	"	3.0	75	8 "	2.0 " 2.5 " 2.2 "	"	.... 8.9 8.9	.... 1601 1565	......	......	......	
6 "	"	"	2.5	48.5	3 "	1 " ..	"	6	......	......	......	......	
7 " Mountain.	"	"	3.0	24	150 lb......	8 oz....	Common shell.....	7	......	......	......	......	
130-pdr....	"	Breach loading.	7.0	126	5 tons 5 cwt.	26 lbs...	Armor piercing with copper bands.	130	......	......	......	......	These cannon are all rifled with shallow grooves about 0.5 in. wide and spaced so that the band is half the width of the groove. The projectiles for these guns are provided with solid drawn copper rings, fixed on them by forcing them through dies which press the rings into grooves turned in the body of the projectile, the projectile being sufficient to allow the ring to take the rifling when the gun is fired.
100 "	"	"	6.3	111	80 cwt	20 " ..	"	100	......	......	......	......	
80 "	"	"	6.0	108	64 "	16 " ..	"	80	......	......	......	......	
60 "	"	"	5.5	101	48 "	15.5 lbs 12.0 "	"	60	1538 1447	984 830	57 48	63.5 69.2	
40 "	"	" ..	4.75	96	30 "	8 lbs..	Solid shot or common shell with copper bands.	40	......	......	......	......	
40 "	"	"	5.5	75.5	32 "	5 " ..	"	40	......	......	......	......	
20 "	"	"	3.75	93	16 "	5 " ..	"	20	......	......	......	......	
20 "	"	"	3.75	67	12 "	3 " ..	"	20	1700	......	......	......	
12 "	"	"	3.0	75	9 "	2.9 lbs.	"	11	......	......	......	......	
9 "	"	"	2.75	52.5	5.5 cwt....	1.5 " ..	"	9	......	......	......	......	
6 "	"	"	2.5	48	3.5 "	1.0 " ..	"	6	......	......	......	......	
4 " Mountain.	"	"	2.2	24	150 lb......	8 oz....	"	4	......	......	......	......	

TABLE 6.

GERMAN CANNON AND PROJECTILES.

MAKER AND KIND OF GUNS.	NATURE OF SERVICE.	WEIGHT.	PREPONDERANCE.	LENGTH.	CALIBRE.	DIAMETER OF CHAMBER.	LENGTH OF BORE.	RIFLING. LENGTH OF CHAMBER.	RIFLING. LENGTH OF RIFLING.	RIFLING. NUMBER OF GROOVES.	RIFLING. TWIST.	CHARGE. WEIGHT OF POWDER.	PROJECTILES. STEEL SHELL.	PROJECTILES. CHILLED STEEL.	PROJECTILES. COMMON SHELL.	INITIAL VELOCITY. WITH STEEL SHELL.	INITIAL VELOCITY. WITH COMMON SHELL.	REMARKS.
KRUPP.		tons.	lb.	in.	in.	in.	in.	in.	in.			lb.	lb.	lb.	lb.	feet per sec.		
30½ centimetre = 12-in. B. L.	S. S.	35.30	......	263.781	12.007	12.401	227.167	....	....	72	1 turn in 71 ft. $5\frac{13}{16}$ in.	132	651.2	....	565.5	1525	1510	All these guns are made of *steel.* Width of groove at *breech* and *muzzle* is different, and also the width of lands. They are all provided with the mechanism of Mr. L. W. Broadwell, an American now residing at Carlsrühe. The gas check is recognized as the "Broadwell ring."
28 " howitzer. = 11 in. B. L.	L. S.	9.82	......	125.985	11.023	....	99.202	....	....	72	1 turn in 36 ft. $8\frac{15}{16}$ in.	44	....	....	437.8	......	......	
Short 26 centimetre = 10.23 in. "	S. S.	17.67	......	204.726	10.236	10.605	174.016	46.062	127.954	64	1 turn in 59 ft. $8\frac{1}{2}$ in.	70.4	404.8	411.40	349.80	1476		
Long 24 " = 9.44 in. "	do.	14.38	......	205.907	9.267	9.606	177.599	43.003	133.996	32	From 1 turn in 54 ft. ¾ in. to 55 ft. $5\frac{11}{16}$ in.	52.8	294.8	305.8	260.70	1410	1391	
Short 24 " = 9.44 in. "	do.	....	......	185.355	9.267	9.606	157.048	41.692	115.356	32	do. do.	52.8	294.8	305.8	260.70	1410	1391	
Long 21 " = 8.26 in. "	L. S.	9.84	......	185.355	8.241	8.547	161.654	37.086	124.568	30	From 1 turn in 46 ft. 8 ¼ in. to 47 ft. $11\frac{9}{16}$ in.	37.4	209.0	217.8	173.8	1440	1440	
Short 21 " = 8.26 in. "	do.	8.84	......	154.449	8.241	8.543	131.221	33.976	97.245	30	1 turn in 40 ft. $6\frac{9}{16}$ in.	37.4	209.0	217.8	173.8	1440	1440	
Long 17 " = 6.69 in. " ...	L. S. & S. S.	5.5	......	167.323	6.771	6.999	148.819	32.480	116.339	48	1 turn in 36 ft. $8\frac{15}{16}$ in.	26.4	117.0	121.22	100.54	1510	1526	
Short 17 " = 6.69 in. "	do.	....	......	133.859	6.771	6.999	117 400	26.771	90.629	48	do. do.	26.4	....	121.22	100.54	1510	1526	
Long 15 " = 5.90 in. "	do.	3.03	55	135.433	5.869	6.074	119.684	25.433	94.251	48	1 turn in 31 ft. 9⅞ in.	17.6	78.10	75.90	67.00	1510	1526	
Long 15 " = 5.90 in. " No. 2	do.	3.9	165	151.536	5.869	6.074	135.040	29.330	105.710	48	do. do.	17.6	78.10	75.90	67.00	1510	1526	
Short 15 " = 5.90 in. "	L. S.	2.9	55	128.741	5.869	6.074	112.255	24.460	87.795	36	do. do.	17.6	78.10	75.90	67.00	1510	1526	
12 " = 4.72 in. "	do.	1.37	220	115.157	4.735	4.921	102.440	16.771	85.689	18	From 1 turn in 23 ft. 8 $\frac{3}{16}$ in. to 1 in 24 ft. 1⅛ in	7.9	39.336	....	33.88	1476	1476	
9 " = 3.54 in. "	do.	935 lbs.	110	80.310	3.602	....	71.614	....	....	16	1 turn in 14 ft. 10¾ in.	1.32	....	....	15.18	......	1056	
8 " = 3.149 in. " ...	do.	649 "	154	76.181	3.090	....	60.031	....	....	12	1 turn in 11 ft. $10\frac{7}{16}$ in.	1.10	....	....	9.46	......	1171	
6 " = 2.362 in. "	do.	235 "	30.8	49.212	2.362	....	44.488	....	....	18	1 turn in 6 ft. 10¾ in.	0.44	....	....	5.06	......	984	

TABLE 7.

FRENCH AND RUSSIAN CANNON AND PROJECTILES.

KIND OF GUNS.	NATURE OF SERVICE.	WEIGHT, THE TON = 2240 lbs.	LENGTH.	CALIBRE.	DIAMETER OF CHAMBER.	LENGTH OF BORE.	RIFLING: LENGTH OF CHAMBER.	RIFLING: LENGTH OF RIFLING.	RIFLING: NO. OF GROOVES.	RIFLING: TWIST.	CHARGE: SERVICE.	CHARGE: BATTERING.	COMMON SHELL: BURSTING CHARGE.	COMMON SHELL: TOTAL WEIGHT.	BATTERING PROJECTILES: WEIGHT.	BATTERING PROJECTILES: DIAMETER OF BODY.	BATTERING PROJECTILES: MATERIAL.	INITIAL VELOCITY—FEET PER SEC.	REMARKS.
FRENCH GUNS.		tons.	in.	in.	in.	in.	in.	in.			lb.	lb.	lb.	lb.	lb.	in.		ft.	
32 centimetre = 12.539 B. L.	S. S.	34.5	224.4	12.599	12.559	204.1	....	....	...	....	136.69	136.69	38.14	631.12	760.57	12.48	Cast iron & steel.	1312	All of these guns are constructed of cast-iron tubed with steel nearly to the trunnions, and strengthened behind the trunnions with steel rings shrunk on. The constant angle of rifling for all calibres is 6° at the muzzle, and the development of the curve is a parabola.
27 " = 10.78 "	do	21.7	211.812	10.803	10.803	163.70	....	....	5	Increasing twist from 0, 1 turn in 30 calibres at muzzle.	52.91	79.38	13.67	317.46	476.4	10.70	do.	1378	
24 " = 9.448 "	L. S. & S. S.	13.8	....	9.499	9.499	162.55	....	....	5	do. do.	35.27	61.74	9.26	220.46	317.6	9.346	do.	1427	
19 " = 7.480 "	do	7.9	149.61	7.638	8.031	135.39	....	....	5	do. do.	17.64	33.1	4.74	45.19	165.4	7.717	do.	1486	
16 " = 6.299 "	do	98.42 cwt	....	6.484	6.484	118.27	....	....	3	do. do.	11.02	16.53	2.87	69.42	99.3	6.389	do.	1312	
14 " = 5.11 "	do	52.26 "	....	5.456	5.456	89.88	....	....	5	....	8.82	8.82	....	....	....	....	do.	1509	
Siege gun of 24 B. L.	L. S.	40.55 "	....	6.010	6.010	79.13	....	....	...	....	....	5.50	....	OBLONG SHELL.	CANISTER.	....	do.	....	
30 (M. L.) not hooped	Sea-Coast Service.	61 "	....	6.48	....	....	....	....	3	....	....	6.60	....	69.46	30.0	....	Cast iron	984.26	Range 6562 yds .... The grooves have a parabolic development, inclined at the muzzle at an angle of 5 to 6°.
30 (M. L. or B. L. hooped)		70.86 "	....	6.48	....	....	....	....	3	....	....	7.72	....	69.46	30.0	....	do.	1066	" 7108 " at angle 38°
18 (M. L. or B. L. hooped)		70.86 "	....	5.46	....	....	....	....	3	....	....	5.5	....	41.10	18.89	....	do.	1066	" do. do.
Howitzer 22 centimetre M. L. = 8.66 in. (rifled and hooped).		....	....	....	....	....	....	....	...	....	....	....	....	179.7	86.01	....	do.	1066	" 5687 yds ....
24 rifled, M. L.	Fortress Guns.	5953 lbs.	....	6.010	....	....	....	....	3	1 turn in 13.12 feet	....	5.50	....	....	53.0	....	Bronze	1072	" 6562 " at angle 30°
12 " "		3307 "	....	4.770	....	....	....	....	3	1 turn in 9.84 do.	....	2.65	....	....	20.00	....	do.	1072	" do. do.
24 " "	Siege.	4409 "	....	6.010	....	....	....	....	3	1 turn in 13.12 do.	....	5.5	....	....	53.0	....	do.	1072	" do. do.
12 " "		1940 "	....	4.770	....	....	....	....	3	1 turn in 9.84 do.	....	2.65	....	....	26.00	....	do.	1072	" do. do.
12 " "	Field Artillery.	1367 "	....	4.770	....	....	....	....	3	do. do.	....	2.205	....	....	26.00	....	do.	1072	" 4484 yds. at angle 30°.
8 " "		1234.6 "	....	4.17	....	....	....	....	3	do. do.	....	1.76	....	16.0 Common shell. 19.4 Shrapnel. 17.78 Canister.			do.	1083	" 3500 yds. " 20°.
4 " "		727.55 "	....	3.40	....	....	....	....	3	1 turn in 7.38 do.	....	1.21	....	8.82 Common shell. 9.92 Shrapnel. 10.36 Canister.			do.	1066	" 3500 yds. " 30°.
4 " Mountain		220.5 "	....	3.40	....	....	....	....	3	do. do.	....	0.66	....	do.	do.		do.	738	" 2953 yds. " 30°.
RUSSIAN GUNS.																			
12-inch, B. L.	S. S.	40.0 lbs.	252	12	12	216	57	159	36	....	....	113.8	....	....	....	....	Steel	....	
8 " "	L. S. & S. S.	8.754 "	175	8	8	151	34	117	30	....	343	....	....	171.2	....	....	do.	1398	
8 " (Mortar) B. L.	....	3.21 "	89.9	8	8	68.5	24.5	44	...	....	....	16.2	....	171.2	....	....	do.	1443	
6 " B. L.	S. S.	3.92 "	140.0	6	6	122.0	32	90	...	....	....	18	....	81.1	....	....	do.	....	
12.2-pdr. boat gun	S. S.	792 "	67.45	....	....	....	....	....	...	....	....	21.5 oz	....	12.2	....	....	do.	1597	

NOTE.—The particulars in the above table relative to French cannon are mostly taken from a table compiled by the Vicomte de Noué, Lieut. Col. of Artillery, and sent to Gen. Barry by the Comte de Paris.

TABLE 8.

COMPARATIVE ENERGY OF PROJECTILES FROM FRENCH, BRITISH, AND GERMAN GUNS.

FRENCH GUNS.			BRITISH GUNS.			GERMAN GUNS.		
KIND OF GUN.	TOTAL ENERGY IN FOOT TONS.	ENERGY PER POUND OF POWDER FOOT TONS.	KIND OF GUN.	TOTAL ENERGY IN FOOT TONS.	ENERGY PER POUND OF POWDER FOOT TONS.	KIND OF GUN.	TOTAL ENERGY IN FOOT TONS.	ENERGY PER POUND OF POWDER FOOT TONS.
in.			in.			in.		
12.599	9077	66.4	12	8205	74.6	11	6953	78.8
10.630	6273	71.1	11	6415	75.5	10.23	5514	78.2
9.448	4484	72.7	10	5160	73.7	9.44	3657	69.1
7.480	2533	76.5	9	3496	69.0	8.26	2889	77.1
6.299	1185	71.8	8	2492	71.2	6.69	2073	81.7
5.511	649	73.6	7	1943	64.8	5.90	1096	80.1
....	......	....	64-pdr	696	87.0	31-pdr	206	89.0

After the report of the Board of Officers was made to the War Department, it was thought advisable to add this appendix on "Serving and Working Heavy Artillery," as practised at the Artillery School, and much of the matter in Parts I., II., III., and IV., of the appendix is taken from the "Artillery School Circulars of 1874," and from the "Heavy Artillery Tactics."

Part V. is taken from "Ordnance Memoranda" Nos. 24 and 32, and Part VI. from "Heavy Artillery Tactics."

APPENDIX, NO. 2.

SERVING AND WORKING HEAVY ARTILLERY.

PART I.

General Directions.

Formation of a company into detachments.

1. The company should be instructed in the school of the soldier and Company as Infantry, and all manœuvres not herein prescribed, will be executed as laid down in the Field Artillery Tactics.

2 The company being formed in two ranks faced to the front will be divided into a number of sections corresponding to the number of pieces to be served. A sec-

tion may comprise one or more detachments, and, if more than one, may be divided into as many complete detachments as it will form; the remaining files, if any, will be added to the left detachment of the section. The senior non-commissioned officers will be assigned as chiefs of pieces, and the junior ones as gunners.

3. Two sections form a platoon commanded by a subaltern, and if circumstances permit, the company will have as many platoons as there are subalterns to command them. The Captain, *in line*, is four yards in front of the centre of the company; in column, on the side of the guide, or on the side towards which the sub-divisions are dressed, four yards from the flank of the column and opposite its centre. When the company is *in line* or in *column of platoons* each commandant of platoon is two yards in front of the centre of his platoon; in column of sections, he is on the side of the guide, or on the side towards which the subdivisions are dressed, two yards from the flank of the column and opposite the centre of his platoon; in column of *files*, each is as if he had faced with the company from line, except the chief of the leading platoon, who takes post at the side of the leading guide.

The chief of piece acts as *chief of section*, and when the company is *in line*, or in column of *platoons*, is on the right of the front rank of his section; in column of sections, he is one yard in front of the centre of his section; in column of *files*, each is as if he had faced with the company from line.

Each gunner, when the company is in line or in column of *platoons* is one yard in the rear of the right of his section; in column of *sections*, on the right of the front rank of his section; in column of *files* each as if he had faced with the battery from line.

The march to the Battery.

4. The instructor wheels the company into column of sections, or faces it by a flank either to the right or left; to the right if he is to approach the battery on the left; and to the left if he is to approach the battery on the right. When the company arrives at the distance of four yards from the left or right of the battery, the instructor commands:

SECTIONS OPPOSITE YOUR PIECES.

As each section arrives in rear of its piece, it is halted by the chief of piece, and wheeled into line or faced to the front and dressed to the right *four* yards in rear of the platform, the centre of the first detachment on the line of the axis of the piece or centre of the platform. Each chief of platoon places himself one yard in front of the centre of his platoon, each chief of piece on the right of his section and the gunner in the front rank on the left of No. 4.

All movements not specially excepted, may be executed in *double time*. If the movement be from a halt, or when marching in quick time, the command *double time* precedes the command *march;* if marching in double time, the command *double time* is omitted.

Telling off the Detachments.

5. The instructor then commands:

CALL OFF.

Each chief of piece steps promptly to the front to see

that the cannoneers call off properly, and then returns to his post. In telling off the detachments, the odd numbers form the rear, and the even numbers and the gunner the front rank. The right file is numbered 1 and 2; the next file 3 and 4; gunner on the left of No. 4, uncovered; the next 5 and 6, &c.

To cause the Cannoneers to take their Posts.

6. The instructor commands:

1. *Cannoneers to your posts.*
2. MARCH.

At the first command the first detachment of each section is faced to the right by the chief of piece who commands: 1. *Right*; 2. FACE; 3. TO YOUR POSTS; and at the second command repeated by the chief of piece files to the left, the two ranks separating; the rear rank marching to the right of the piece, and the front rank to the left. As each man arrives at his post, he halts and faces the piece; Nos. 1 and 2 one yard from the epaulment, parapet, or scarp, their breasts *eighteen* inches outside the wheels of the carriage or cheeks of the mortar bed; and the remaining numbers and the gunner dressing respectively on Nos. 1 and 2 at intervals of *one* yard, except that between Nos. 3 and 5, there is an interval of *two* yards. With the mortar, Nos. 1 and 2 are opposite the front manœuvring bolts, and Nos. 3 and 4 opposite those in rear. The gunner *one yard* on right of No. 4. The chief of the piece, while at the battery, will generally be *one* yard outside the cannoneers of the left, facing the piece, and *two* yards in rear of the platform or rearmost part of the carriage.

To Allow the Detachments to Rest.

7. The instructor commands:

In place—REST, or REST.

The cannoneers lay down their handspikes, as prescribed in par. 11, siege gun. In the first case the men remain at their posts; in the second case, they may leave their posts, but must remain near the piece.

To Resume the Exercise.

8. The instructor commands:

1. *Detachments* 2. ATTENTION.

All resume their posts and handspikes.

To change Posts.

The instructor commands:

1. *Change Posts.*
2. MARCH.
3. CALL OFF.

At the first command the cannoneers lay down their handspikes; place their equipments on the parts of the carriage nearest them, or on the platform, and face to their left. At the next command they step off, each advancing one post; No. 2 taking that of No. 1. On

arriving at their new posts they face the piece and equip themselves. At the third command they call off according to the posts they then occupy.

To leave the Pieces.

The instructor commands:

1. *Detachments, rear.*
2. MARCH.

At the first command, the chief of piece faces the detachment to the rear by the commands, 1. *Left and right,* 2. FACE; and at the second, repeated by the chief of piece, it marches to the rear, the left cannoneers closing on those of the right, files to the right, and is halted, faced to the front, and with its section dressed to the right by the chief of piece, so as to bring its centre on a line with the axis of the piece or opposite the middle of the platform, and four yards in rear of it.

To re-form the Company and leave the Battery.

1st. *In column of files.*

The instructor commands:

1. *Sections, right (or left),* 2. FACE.
3. *Close,* 4. MARCH.

At the first command, the sections face to the right (or left), the gunners taking their places in the rank of file-closers, and at the command MARCH, repeated by all the

chiefs of pieces, (except the leading one,) the right or left section stands fast, and the others close on the one in front of it, and are halted by their chiefs of pieces.

2d. *In column of Sections.*

The instructor commands:

1. *Sections right (or left) wheel*, 2. MARCH, 3. *Close to wheeling distance*, 4. *Guide (right or left)*, 5. MARCH.

At the second command, each section wheels to the right and is halted and dressed to the left by its chief; at the third command the chief of the leading section cautions it to stand fast; at the fifth command, all the sections in rear of the first, step off, and each is halted by its chief when at wheeling distance from the preceding section.

SERVICE OF A BATTERY OF SEVERAL PIECES.

The pieces are numbered from right to left. In directing them to be fired, they are always designated by their numbers, as, *Number one*—FIRE; *Number two*—FIRE, &c.

When the wind comes from the right, the firing should commence on the left, and reciprocally.

In mortar batteries (which should not exceed three or four pieces), the cannoneers remain at their posts until the signal, or command, COMMENCE FIRING; all then move to the rear of the platform, except No. 3 of the mortar which is to commence firing, and are formed as in *de-*

tachment rear, leaving No. 4 of the piece to be fired uncovered. (In the service of a single mortar the detachment forms in rear as prescribed in par. 45, service of 10 inch siege-mortar). So soon as this mortar is fired, No. 3 joins his detachment, and No. 3 of the next mortar goes to his piece, and, at the proper command, fires it, and then rejoins his detachment, and so on. Each detachment remains in its position until all the pieces having been discharged, the signal, or command, TO YOUR POSTS, is given.

A similar precaution may be necessary to avoid the blast in a battery composed entirely of howitzers, or heavy sea-coast guns.

SERVICE OF A GUN MOUNTED ON A SIEGE CARRIAGE.

Seven men are necessary; one gunner and six other cannoneers.

8. The implements, &c., are arranged as follows:

Handspikes—three on each side of the carriage, leaning against the epaulment, in line with the cannoneers.

Sponge, *Rammer*—one yard behind, and parallel to the line of cannoneers of the right, the sponge uppermost, the sponge and rammer-heads turned from the epaulment and supported on a prop.

Pass-box—against the epaulment, outside the pile of balls.

Primer-pouch—containing friction-primers and the lanyard, which is wound upon its handle. Suspended from the cascable.

Gunner's-pouch—containing the gunner's level, breech-

sight, finger-stall, priming-wire, gimlet, vent-punch, and chalk. Suspended from the cascable.

Chocks—one on each side of the piece, near the ends of the hurter.

Vent-cover—covering the vent.

Tompion—in the muzzle,

Broom—leaning against the epaulment, outside of the pile of balls.

There should be one gunner's level, two vent-punches. one worm, one ladle, and one wrench to a battery not exceeding six pieces.

The balls are piled on the left of the piece near the epaulment, and close to the edge of the platform.

The wads are placed between the epaulment and the balls, partly resting on them.

To cause the implements to be distributed.

The instructor commands:

TAKE IMPLEMENTS.

9. The gunner steps to the cascable; takes off the vent-cover, handing it to No. 2. to place against the epaulment, outside the pass-box: gives the primer-pouch to No, 3; equips himself with his own pouch and the finger-stall, wearing the latter on the second finger of the left hand; levels the piece by means of the elevating-screw; applies his level to ascertain the *highest points* of the base-ring and swell of the muzzle, *which* he marks with chalk, and resumes his post.

No. 3 equips himself with the primer-pouch. Nos. 1 and 2 after passing two handspikes each to Nos. 3 and

4, take each one for himself. Nos. 5 and 6 receive theirs from Nos. 3 and 4.

10. The handspike is held in both hands, the hand nearest the epaulment grasping it near the small end and at the height of the shoulder, back of the hand down, elbow touching the body; the other hand back up, the arm extended naturally; the butt of the handspike upon the platform, on the side farthest from the epaulment, and six inches in advance of the alignment.

11. When the cannoneer lays down his handspike, he places it directly before him, about six inches in front of and parallel to the alignment, the small end toward the epaulment; and whenever he thus lays it down for the discharge of any particular duty, he will take it up on returning to his post after having completed that duty.

The service of the piece is executed as follows:

The instructor commands:

1. FROM BATTERY.

12. The gunner moves two yards to his right. Nos. 1, 2, 3, 4, 5, and 6, facing from the epaulment, embar: Nos. 1 and 2 under the front of the wheels; Nos. 3 and 4 through the rear spokes of the wheels near the felly, under and perpendicular to the cheeks; Nos. 5 and 6 under the manœuvring bolts. When all are ready, the gunner gives the command HEAVE, which will be repeated as often as may be necessary. He sees that Nos. 5 and 6 guide the trail in prolongation of the directrix of the embrasure, and as soon as the face of the piece is about *one* yard from the epaulment, commands HALT, at which all unbar and resume their posts. Nos. 1 and 2 chock the wheels.

2. *Load by detail*—LOAD.

13. Nos. 1, 2 and 4 lay down their handspikes. No. 2 takes out the tompion, and places it near the vent-cover. No. 1 faces once and a half to his left; steps over the sponge and rammer, faces to the piece, takes the sponge in both hands, the backs down, the right hand three feet from the sponge-head, the left hand eighteen inches from it; returns to the piece, entering the staff in the embrasure; places the left foot half way between the wheel and the face of the piece, in line with the latter; breaks to the right with the right foot, the heels on a line parallel to the piece, the left leg straightened, the right knee bent, the body erect upon the haunches, and rests the end of the sponge in the muzzle, the staff in the prolongation of the bore supported by the right hand, the right arm extended, the left hand flat against the side of the thigh. No. 2 steps to the muzzle, and occupies a position on the left of the piece corresponding to that of No. 1 on its right. He seizes the staff with the left hand, back down, near to and outside the hand of No. 1. No. 3 facing the epaulment, embars under the breech, and maintains the piece in a convenient position for the insertion of the sponge, until the gunner signals to him to unbar. He then lays down his handspike, steps over the rammer, and seizes the staff as prescribed for the sponge; and stands ready to exchange with No. 1. No. 4 takes the pass-box and goes for a cartridge; returns and stations himself, facing the piece, about eighteen inches to the rear and right of No. 2. The gunner places himself near the stock, his left foot advanced; closes the vent with the second finger of the left hand, bending forward to cover himself by the breech; turns the elevating screw with the right hand to adjust the muzzle

conveniently for loading; and makes a signal to No. 3 to unbar. In the mean time, Nos. 1 and 2, at the words ONE—TWO—THREE, &c., insert the sponge by the following motions: 1*st Motion*. They insert the sponge as far as the hand of No. 1, bodies erect, shoulders square. 2*d Motion*. They slide the hands along the staff, and seize it at arm's length. 3*d Motion*. They repeat the first motion. 4*th Motion*. They repeat the second motion. 5*th Motion*. They force the sponge to the bottom of the bore. No. 1 then replaces his left hand on the staff, back up and six inches nearer the muzzle than his right. No. 2 places his right hand, back up, between the hands of No. 1. Should the sponge or the rammer reach the bottom of the bore at the *third or fourth motion*, then what is prescribed for the *fifth motion* will be performed at the third or fourth. The knee on the side toward which the body is to be inclined is always bent, the other straightened; and the weight of the body added as much as possible to the effort exerted by the arms.

3. SPONGE.

14. Nos. 1 and 2 pressing the sponge firmly against the bottom of the bore, turn it three times from right to left, and three times from left to right; replace the hands on the thighs, and withdraw the sponge by the same commands and by motions contrary to those for inserting it. When the sponge fits tight, Nos. 1 and 2 may use both hands. No. 2 quits the staff, and turning toward No. 4, receives from him the cartridge, taking it in both hands, backs down, and introduces it bottom foremost into the bore, seams to the sides; he then grasps the rammer in the way prescribed for the sponge. No. 1 rising upon the

right leg, and turning to his left, passes the sponge above the rammer to No. 3 with his left hand, and receiving the rammer with the right, presents it as prescribed for the sponge, except that he rests the rammer-head against the right side of the face of the piece. No. 3, as soon as the sponge is withdrawn, passes the rammer under the sponge into the embrasure with the right hand, receives the sponge from No. 1 with the left, replaces it upon the prop, and resumes his post. No. 4, setting down the pass-box, takes out the cartridge and presents it in both hands to No. 2, the choke to the front; returns the pass-box to its place; and picks up a ball, and afterward a wad, if required. Nos. 1 and 2 force the cartridge home by the same commands and motions as in case of the sponge.

4. Ram.

15. Nos. 1 and 2, drawing out the rammer to the full extent of their arms, ram with a single stroke. No. 2 quits the staff, and turning toward No. 4, receives from him the ball, and a *wad if required*, whilst No. 1 throws out the rammer, and holds the head against the right side of the face of the piece. No. 2, introducing the ball and wad into the bore, seizes the staff with the left hand, back down. No. 4 then resumes his post. Nos. 1 and 2 force the ball and wad home together by the same commands and motions, and ram in the same manner as prescribed for the cartridge, except that in case of a shell it is simply *pressed* home. No. 2 quits the rammer; sweeps, if necessary, the platform on his side; passes the broom to No. 1; and resumes his post. No. 1 throws out the rammer, and replaces it on the prop under the sponge; sweeps his side of the platform, if necessary, passes the broom to

No. 2 who replaces it and then resumes his post. The gunner pricks the cartridge, leaves the priming wire in the vent, and resumes his post; and, if firing beyond point blank, adjusts the breech-sight to the distance.

5. In Battery.

16. Nos. 1 and 2 unchock the wheels, and with Nos. 3, 4, 5, and 6, all facing toward the epaulment, embar: Nos. 1 and 2 through the front spokes of the wheels near the felly, under and perpendicular to the cheeks; Nos. 3 and 4 under the rear of the wheels; and Nos. 5 and 6 under the manœuvring bolts. When all are ready, the gunner commands Heave, and the piece is run into battery; Nos. 5 and 6 taking care to guide the chase into the middle of the embrasure. As soon as the wheels touch the hurter, he commands Halt. All unbar, and Nos. 1, 2, 3 and 4 resume their posts.

6. Point.

17. No. 3 lays down his handspike; passes the hook of the lanyard through the eye of a primer from front to rear, and holds the handle of the lanyard in the right hand, the hook between the thumb and forefinger. Nos. 5 and 6 embar under and perpendicularly to the trail near the manœuvring-bolts. The gunner, placing himself at the stock, as at the command Load, withdraws the priming wire, and, assisted by Nos. 5 and 6, gives the direction; causing the trail to be moved by commanding Left, or Right, tapping, at the same time, on the right of the breech for No. 5 to move the trail to the left, or on the

left side for No. 6 to move it to the right. He then places the centre of the breech-sight accurately upon the chalk mark on the base-ring, and by the elevating-screw, gives the proper elevation, rectifying the direction, if necessary. The moment the piece is pointed, he rises on his left leg, and gives the word READY, signalling with both hands, at which Nos. 5 and 6 unbar, and resume their posts; takes the breech-sight in his left hand, and goes to the windward to watch the shot. No. 3 inserts the tube into the vent; drops the handle, allowing the lanyard to uncoil as he steps back to his post, holding it slightly stretched with his right hand, the cord passing between the fingers, back of the hand up, and breaks to the rear a full yard with the left foot, the left hand against the thigh. At the word READY, Nos. 1 and 2 take up the chocks, and breaking off with the feet farthest from the epaulment, stand ready to chock the wheels, holding their handspikes near the centre, small end to the rear, in the hand furthest from the epaulment, arm extended, back of the hand down.

7. *Number one* (or the like)—FIRE.

18. No. 3 pulls smartly on the lanyard. Immediately after the discharge of the piece, Nos. 1 and 2 chock the wheels, and resume the erect position. No. 3 resumes the erect position, and rewinds the lanyard, returning it, if dry, to the primer-pouch. The gunner, having observed the effect of the shot, returns to his post.

To load for action and fire.

19. The instructor commands :

1. *Load*, 2. FIRE.

At the first command the piece is run from battery, loaded, run into battery, pointed, and prepared for firing by the following commands from the gunner: FROM BATTERY—LOAD—IN BATTERY—POINT—READY. At the command FIRE from the instructor, the piece is fired as prescribed above.

If the instructor commands:

1. *Commence*, 2. FIRING.

The gunner gives the same commands as before with the additional command, FIRE, and continues to load and fire until the instructor commands.

1. *Cease*, 2. FIRING.

When ammunition is used, the instructor commands: *With cartridges* (*canister*, *shell*, etc., specifying the particular kind) before commanding *Load, or commence firing.*

At the command 1. *Cease*, 2. FIRING, the piece is sponged out and all resume their posts.

To secure Piece, and replace implements.

20. The piece being *In Battery* the instructor commands:

1. SECURE PIECE.

No. 2 replaces the tompion in the muzzle. The gun-

ner puts on the vent-cover, which he receives from No. 2, and depresses the muzzle.

2. REPLACE IMPLEMENTS.

Nos. 1 and 2 replace the handspikes against the epaulment, those of Nos. 3, 4, 5 and 6 being passed to them by Nos. 3 and 4. The gunner hangs the pouches upon the cascable.

To serve the Piece with reduced numbers.

21. The smallest number of men with which siege guns can be served with facility is *five*. It may be necessary to employ a less number.

With four men. They will be told off as gunner, and Nos. 1, 2 and 3. No. 2 will, in addition to his own duties, perform those of No. 4.

With three men. They will be told off as gunner, and Nos. 1 and 2. No. 1, in addition to his own, performs the duties of No. 3, and No. 2 those of No. 4 as in the preceding case. When No. 2 serves ammunition, he goes for the cartridge, and places the pass-box behind his post before he assists No. 1 to sponge.

SERVICE OF A 24-PDR. HOWITZER, MOUNTED ON A FLANK CASEMATE CARRIAGE.

Three men are necessary: one gunner and two other cannoneers.

22. The implements are arranged as follows:

Roller handspike.—Leaning against the scarp wall, behind No. 2.

Sponge and Rammer.—Leaning against the scarp wall, behind No. 1, the rammer-head upon the ground.

Cartridge-pouch.—Suspended from the cascable.

Primer-pouch.—Containing, in addition to friction-primers, and lanyard, fingerstall and priming-wire. Suspended to cascable.

Vent-cover, tompion.—Same as in siege gun, par. 8.

Broom.—On the left of piece.

Budge-barrel.—Containing cartridges, and placed at some safe and convenient position in rear of the piece.

The rounds of canister are against the scarp wall, behind No. 2.

Shells, if used, are brought to the place prescribed for the budge-barrel.

To cause the implements to be distributed.

The instructor commands:

TAKE IMPLEMENTS.

23. The gunner takes from the primer-pouch the priming-wire and fingerstall, wearing the latter on the second finger of the *right* hand ; gives the primer-pouch to No. 1 and the cartridge-pouch to No. 2; takes off the vent-cover and lays it against the scarp wall, outside the canisters ; takes the roller handspike in his right hand and resumes his post. He holds this handspike vertically in the right hand, the lower end towards the ground in line with the toes, the arm extended naturally. No. 2 wears the cartridge-pouch from the right shoulder to the left side.

To cause the service of the piece to be executed.

The instructor commands:

1. FROM BATTERY.

24. The gunner, embarring in the left mortice, presses the roller under the rear transom, and seizes the left handle with his left hand. Nos. 1 and 2 lay hold of the manœuvring rings and handles. All being ready, the gunner commands HEAVE, and the carriage is run to the rear until the face of the piece is about *one* yard from the wall, when, disengaging the roller, he commands HALT. All resume their posts, the gunner leaving the handspike in the mortice.

2. *Load by detail*—LOAD.

25. No. 2 takes out the tompion and places it in rear of his post. The gunner places himself at the breech, breaks to the rear with the right foot, closes the vent with the second finger* of the right hand, and manages the elevating screw with his left. No. 1, seizing the sponge-staff at its middle, brings it across his body, plants his left foot opposite the muzzle, close to the carriage, and breaks off with his right foot; at the same time dropping the sponge-staff into the left hand, back down, and extending both hands towards the ends of the staff, he brings the sponge opposite the muzzle. He then inserts it, and presses it to the bottom of the chamber with *three* motions, at the words ONE—TWO—and THREE. No. 2 goes for a cartridge, and returns to his post. If shells are used, he brings one up at the same time.

3. SPONGE.

26. No. 1, using both hands, sponges the chamber carefully; withdraws the sponge, pressing it against the bottom of the bore; stepping to his left he turns it over, and rests the rammer-head against the right side of the face of the piece. No. 2 introduces the cartridge in the usual manner, and No. 1 sets it home with the right hand by the same commands and motions as in case of the sponge.

4. RAM.

27. No. 1, drawing out the rammer to the full extent of his arm, rams once, and throws out the rammer, holding it with the rammer-head against the right side of the face of the piece. No. 2 introduces the canister or shell and resumes his post. No. 1 sets the canister or shell home with care, throws out the rammer, replaces it, and resumes his post. The gunner pricks, leaving the priming-wire in the vent, and resumes his post.

5. IN BATTERY.

28. All apply themselves to the carriage, as prescribed in par. 24, and ease the piece into battery. As soon as it touches the hurters, the gunner commands HALT, and all resume their posts.

6. POINT.

29. No. 1 makes ready a primer as prescribed for No. 3 in siege gun, par. 17, and No. 2 going to the rear of the

chassis and facing to the front traverses the chassis by hand. The gunner withdraws the priming-wire, points the piece, and gives the command READY, making a signal with both hands, at which No, 2 resumes his post; takes out the roller handspike, and resumes his post.

7. *Number one* (or the like)—FIRE.

No. 1 does what is prescribed for No. 3 in siege gun, par. 18.

SERVICE OF AN 8-INCH SIEGE HOWITZER, MOUNTED ON A 24-PDR. SIEGE CARRIAGE.

Five men are necessary: one gunner and four other cannoneers.

30. The implements, &c., are arranged as follows:

Handspikes.—Two on each side of the carriage, leaning against the epaulment in line with the cannoneers.

Sponge and Rammer.—On a prop eighteen inches behind, and parallel to the cannoneers of the right, the sponge-head turned toward the epaulment.

Cartridge-pouch.—Containing fuzes, a pair of sleeves, and a priming-wire, bent at right angles at the point for withdrawing the cartridge used in instruction. Suspended from the cascable.

Primer-pouch. *Gunner's-pouch.*	As in par. 8.
Loading-tongs. *Quadrant.* *Plummet.* *Scraper.* *Wiper.* *Splints.*	In a basket, or on a shelf, against the epaulment, outside of, and near the handspikes of the left.

Grummet-wad.—On the end of the hurter, near No. 2.
Chocks. }
Vent-cover. } As in par. 8.
Tompion. }
Quoin.—Under the breech.
Broom.—Leaning against the epaulment outside of the basket or shelf.

To cause the implements to be distributed.

The instructor commands:

TAKE IMPLEMENTS.

31. Executed as in par. 9, with the following modifications: No. 2 places the vent-cover outside the basket; the cartridge-pouch is handed to No. 4 by the gunner. The gunner directs No. 3 to raise the breech, to enable him to level the piece. No. 2 puts on the sleeves, which are taken out of the cartridge-pouch by No. 4, who assists No. 2 to put them on. No. 4 wears the cartridge-pouch from the right shoulder to the left side. Nos. 1 and 2, after passing a handspike each to Nos. 3 and 4, takes each one for himself. The handspike are held, laid down, and resumed as prescribed in pars. 10 and 11.

To cause the service of the piece to be executed.

The instructor commands:

1. FROM BATTERY.

32. Executed as in par. 12, with the following modifi-

cations: Nos. 1, 2, 3, and 4 embar, as prescribed for Nos. 3, 4, 5, and 6. The gunner commands HALT as soon as the *wheels* are about *one* yard from the epaulment.

2. *Load by detail*—LOAD.

33. Executed as in par. 13, with the following modifications: No. 2, after laying down the tompion, sweeps, if necessary, his side of the platform, passes the broom to the right side of the piece, and resumes his post. No. 1 faces to his right and seizes the sponge-staff at its middle with his right hand, back up; places himself at the muzzle, forces the sponge to the bottom of the bore. No. 3, after receiving a signal from the gunner to unbar, resumes his post. No. 4 goes for a cartridge and shell, puts the former in his cartridge-pouch, takes the shell in both hands, and places it on the grummet-wad, and stands, facing the piece, about 18 inches to the rear and left of No. 2. The gunner adjusts the piece at about one degree's elevation before he signals to No. 3 to unbar.

3. SPONGE.

34. No. 1 seizes the sponge-staff with the left hand, back down, and pressing the sponge firmly against the bottom of the bore, turns it three times from right to left and three times from left to right, draws it out, turns the sponge-head over towards the front, and places the rammer-head against the right side of the face of the piece holding the staff in both hands, back of left up and of right down, and, as soon as the cartridge is inserted, inserts the rammer, and holds it with the head against the cartridge, the staff in the axis of the piece.

No. 4 having given the cartridge to No. 2, removes the stopper from, and inserts the fuze into, the fuze-plug; scrapes its end; faces to the left; takes the tongs and wiper, entering the hooks of the former into the ears of the shell in readiness for No. 2.

No. 2, as soon as the sponging is completed, receives the cartridge from No 4, and taking a corresponding position to No. 1, inserts the cartridge, choke to the front (seams to the side). He then makes a face and a half to his left on the right heel, advances the left foot, takes hold of the tongs; raises the shell about two feet from the ground, while No. 4 wipes it.

4. RAM.

35. No. 1 pushes the cartridge home, presses firmly upon it; throws out the rammer, and places it upon the prop; sweeps, if necessary, his side of the platform; passes the broom to the left side of the piece and resumes his post. No. 2 having received the shell, makes a face and a half to his right on the right heel, and breaks off with the left foot: introduces the shell, keeping the legs of the tongs in a vertical plane, left hand nearest the body, and sets the shell carefully against the cartridge, taking care that the fuze is in the axis of the piece.

If the piece is to be fired horizontally, or at an angle of depression, No, 4 having replaced the wiper, hands a splint to No. 2 and resumes his post.

No. 2 presses the splint under the shell with the left hand, replaces the tongs and broom and resumes his post. The gunner pricks, leaving the priming-wire in the vent, and resumes his post.

5. In Battery.

36. Nos. 1 and 2 unchock the wheels, and with Nos. 3 and 4, all facing towards the epaulment, embar: Nos. 1 and 2 through the front spokes of the wheels, near the felly, under and perpendicular to the checks; Nos. 3 and 4 under the manœuvring bolts and parallel to the stock, guiding the muzzle of the piece into the middle of the embrasure. The gunner commands Heave, and, as soon as the wheels touch the hurter, Halt, when all unbar and resume their posts.

6. Point.

37. Executed as in par. 17, with the following modifications: Nos 1 and 4 perform what is prescribed for Nos. 5 and 6. No. 2, facing towards the epaulment, embars under the breech or cascable, and lowers or elevates it at the command of the gunner. When he gives the word Ready, Nos. 1, 2, and 4 unbar and resume their posts.

7. *Number one* (or the like)—Fire.

Executed as in par. 18.

To unload.

38. The piece having been run from battery, the instructor directs No. 2 to take out the shell and cartridge. No. 3 raises the breech until the shell rolls to the muzzle. No. 4 carries them to their place in rear of the piece.

To scrape the Piece.

39. The piece is first moved from battery, and the in-

structor then commands: SCRAPE THE PIECE. Nos. 1 and 2 lay down their handspikes, No. 2 takes the scraper and wiper, giving the latter to No. 1, thoroughly scrapes the bore, draws out the scrapings with the spoon, returns the scraper to its place, and resumes his post. No. 1, enveloping the sponge-head in the wiper, wipes out the bore, and returns the wiper to No. 2, who replaces it, puts the sponge upon the prop, and resumes his post.

SERVICE OF A 10-INCH SIEGE MORTAR.

Five men are necessary: one gunner and four other cannoneers.

40. The implements, etc., are arranged as follows:

Handspikes.—Two against each cheek, leaning upon the four manœuvring bolts, the small end toward the epaulment, the ends of the front handspike even with the front of the cheeks.

Cartridge-pouch.—Containing fuzes, and a pair of sleeves. Attached to the tompion, and lying upon the mortar.

Primer-pouch.—Containing the priming-wire, friction-primers, and the lanyard, wound in St. Andrew's cross upon its handle. Attached to the tompion, and lying upon the mortar.

Gunner's-pouch.—Containing the gunner's level, gimlet, vent-punch, and chalk. Attached to the tompion, and lying upon the mortar.

Quadrant, Plummet, Pointing-cord, Scraper, Wiper, Shell-hooks.—In a basket, between the cheeks of the mortar bed.

Tompion.—In the muzzle.

Pointing-stakes, Maul, Broom.—With the basket.

Iron elevating-bar for pointing.—Laid perpendicular to the cheeks over the rear notches, handle to the left.

To the same battery there should be one *hammer-wrench.*

To cause the Pointing Stakes to be established in position.

The instructor commands:

PLANT THE POINTING-STAKES.

41. The gunner, assisted by Nos. 1 and 2, plants the stakes as explained in Part II., Section 2. No. 1, having driven the pointing-stakes, drives another stake *one* yard behind his post, for holding the wiper, and replaces the maul near the basket. The gunner lays the slack of the pointing-cord at the foot of the epaulment, leaving the plummet at the stake in rear of the piece. All then resume their posts.

To cause the Implements to be distributed.

The instructor commands:

TAKE IMPLEMENTS.

42. The gunner steps to the front of the piece, gives to No. 1 the sleeves and the wiper; to No. 2 the basket and maul; to No. 3 the primer-pouch and broom; and to No. 4 the cartridge-pouch; equips himself with the gunner's-pouch, applies his level to ascertain the line of metal, which he marks with chalk, and resumes his post. No. 1 hangs the wiper on the stake behind his post, and, assisted by No. 3, puts on the sleeves. No. 2 removes the tom-

pion, which he places with the basket and maul one yard behind him, and lays the shell hooks on the ground between himself and the basket. No. 3 lays the broom behind him, and equips himself with the primer-pouch. No. 4 puts on the cartridge-pouch, which he wears from the right shoulder to the left side, and places the elevating-bar behind him perpendicular to the axis of the piece. All take their handspikes. These are held as in par. 10, and when laid down they are returned, except in *one* case, to their places on the manœuvring bolts.

To cause the service of the Piece to be executed.

The instructor commands:

1. In Battery.

43. The gunner, making a half face to his right, steps off, left foot first, and places himself two yards in rear of the platform, facing the piece. Nos. 1, 2, 3, and 4, facing the epaulment, embar; Nos. 1 and 2 under the front manœuvring bolts, and Nos. 3 and 4 under those in rear, engaging the butts of their handspikes about three inches. All being ready, the gunner commands Heave, which will be repeated until the piece is on the middle of the platform, when he commands Halt, at which all unbar, and resume their posts.

Nos. 1 and 3 hold the small end of their handspikes in their left hands, Nos. 2 and 4 in their right.

From Battery.

Executed inversely to above.

REMARK.—When the bed has no rear manœuvring bolts, Nos. 3 and 4 embar under the rear notches perpendicular to the cheeks at the command FROM BATTERY, and in prolongation of the cheeks at the command IN BATTERY.

2. *Load by detail*—LOAD.

Nos. 1, 3, and 4 lay down their handspikes. The gunner, taking the scraper, places himself in front of the muzzle, and scrapes the bore, draws out the scrapings with the spoon, returns the scraper to the basket, and again places himself at the muzzle, one yard in front. No. 1, turning to his right, takes the wiper with his right hand, faces to his left, and placing the left foot near the manœuvring bolt, the right in front of the muzzle, and the left hand upon the face of the piece, wipes out the bore, and resumes his post. No. 3, as soon as the piece is wiped, clears the vent with the priming-wire, sweeps the platform, if necessary, and resumes his post and handspike. Nos. 2 and 4, facing to their right—No. 2 holding his handspike at the middle, under his left arm, butt-end to the front, and taking the shell-hooks in his right hand—goes for a cartridge and shell. While No. 4 is getting the cartridge, No. inserts the shell-hooks into the ears of the shell, and passes the small end of the handspike through the ring. In carrying the shell, they hold the handspike in their right hands, No. 4 at the small end, and in advance of No. 2. Passing by the left of the piece, between the gunner and the muzzle, they rest the shell upon the platform, against the middle of the transom. No. 1, first placing the wiper upon the handspike, receives its small end from No 4, who then gives the cartridge to the gunner The gunner, advancing the left foot, places his left hand

on the face of the piece, introduces the cartridge into the bore with the right hand, and carefully pours in the powder, returns the bag to No. 4, and spreads the powder evenly over the bottom of the bore. If firing with paper fuzes, he receives one from No. 4, and inserts it in the fuze plug. No. 4 returns the cartridge-bag to the cartridge-pouch and takes the wiper. Nos. 1 and 2 raise the shell, and hold it about a foot from the ground, while No. 4 wipes it; they then lift it into the muzzle. The gunner steps forward, and with his left hand over the handspike, the right hand under and nearer to it, seizes the shell-hooks, and assists in lowering the shell gently into its place. No. 2 then withdraws the handspike from the ring and resumes his post. No. 1 takes up his handspike. The gunner sees that the fuze is in the axis of the piece, and throws the shell-hooks to their place behind No. 2; if firing with wooden fuzes, he uncaps the fuze. No. 4, after wiping the shell, returns the wiper to its place, lays the slack of the pointing cord over the left manœuvring bolts, its end at the rear pointing-stake, and resumes his post and handspike.

3. Point.

44. No. 4 embars with the iron elevating-bar through the fulcrum in the ratchets of the mortar, and raises or lowers the breech at the command of the gunner. The gunner applies the quadrant to the left side of the face of the piece, giving the command to No. 4 Raise or Lower, until the piece is at the required elevation—usuallly 45°, makes a signal to No. 4, who then unbars, places the elevating-bar behind him, and perpendicular to the axis of the piece, and resumes his post. The gunner

returns the quadrant to the basket and places himself behind the rear pointing-stake, and holding the pointing cord in the left hand and the plummet in the right, gives the direction, commanding MORTAR LEFT, MORTAR RIGHT, MUZZLE LEFT, MUZZLE RIGHT, TRAIL LEFT, TRAIL RIGHT, according to circumstances.

To throw the mortar to the left. No. 2 embars under the left front manœuvring-bolt, from the front; No. 1 under the right front notch; No. 3 under the left rear notch from the inside; Nos. 1 and 3 facing to the front, No. 5 to the rear. When all are ready the gunner gives the commands HEAVE—STEADY. The cannoneers remain embarred until he gives some other command, or makes the signal to unbar.

To throw the mortar to the right. No. 1 embars under the right front manœuvring-bolt from the front; No. 2 embars under the left front notch; No. 4 embars under the right rear notch from the inside; No. 1 faces to the rear, and Nos. 2 and 4 face to the front.

To throw the muzzle to the left. No. 2 embars under the left front manœuvring-bolt, from the front; No. 1 under the right front notch, perpendicular to the cheeks, and facing to the front.

To throw the muzzle to the right. No. 1 embars under the right front manœuvring-bolt, from the front; No. 2 embars under the left front notch perpendicular to the cheeks, facing to the front.

To throw the trail to the left. No. 3 embars the under left rear notch, from the inside, facing to the front.

To throw the trail to the right. No. 4 embars under the right rear notch from the inside, facing to the front.

45. The direction having been given, the gunner gives the word READY, and makes a signal with both hands

leaves the plummet at the rear stake, returns the pointing cord to the foot of the epaulment, and goes to observe the effect of the shot. Nos. 1, 2, and 4, taking their handspikes, go four yards in rear of the platform and face to the front. No. 4 between Nos. 1 and 2, their handspikes held erect by the right side, the right arm extended naturally. No. 3 lays down his handspike six inches in his front, parallel to the edge of the platform, and makes ready a friction-primer as in par. 17; advancing the right foot, he inserts the primer in the vent, rises on the left leg, and moves three yards to the rear in prolongation of the right cheek, faces to the piece, and holds the handle of the lanyard, and breaks off as prescribed in par. 17.

The lanyard should be passed under the pipe.

4. *Number one* (or the like)—FIRE.

Executed as in par. 18.

On the discharge of the piece, all but the gunner resume their posts. As soon as the shot strikes, he returns to his post.

46. To continue the exercise, the instructor causes the piece to be moved toward the rear of the platform by the command—FROM BATTERY, directs Nos. 2 and 4 to take out the shell and carry it to its place in rear, and then resumes the series of commands, beginning with IN BATTERY.

In changing posts, No. 2 passes by the front of the piece.

To secure Piece and replace implements.

47. The piece having been placed as at the command

IN BATTERY, the instructor gives the command REPLACE IMPLEMENTS, at which all lay down their handspikes. No. 2 puts in the tompion, and assists No. 1 to pull up the pointing-stakes. The gunner receives the implements and replaces them between the cheeks, No. 4 replacing the elevating-bar across the rear notches.

SERVICE OF AN 8-IN. SIEGE MORTAR.

Three men are necessary: one gunner and two other cannoneers.

48. The implements, etc., omitting *two* hand-spikes, and adding a *grummet-wad*. are the same as for the 10-inch siege mortar, and are arranged in the same manner. The grummet-wad is in the basket.

49. The service of this piece is the same as that prescribed for the 10-inch siege mortar, with the following modifications: at the command TAKE IMPLEMENTS, No. 1 performs the duties of No. 3, and No. 2 those of No. 4, each in addition to his own. No. 2 assists No. 1 to put on the sleeves, and places the wad on the platform, in front of the transom. At the command IN BATTERY, Nos. 1 and 2 embar under the front manœuvring-bolts, facing to the front. At the command FROM BATTERY, No. 1 embars under the right front manœuvring-bolt and No. 2 under the left rear bolt, both facing from the parapet. If the mortar-bed have no rear manœuvring-bolts, No. 2 embars under the left rear notch nearly perpendicular to the cheek. At the command LOAD, No. 1, having wiped out the mortar, returns the wiper to the stake, pricks, and, if necessary, sweeps the platform. No. 2, laying down his handspike, goes for a cartridge and shell, carries the shell in the right arm, passes between the

gunner and the muzzle, and lays it on the wad, gives the cartridge, and—if firing with paper fuzes—a fuze to the gunner, and takes the wiper from the stake. The gunner, on returning the scraper to the basket, takes the shell-hooks, and lays them on the ground in front of the muzzle. Having poured in the powder, he returns the cartridge bag to No. 2, and distributes the powder evenly over the bottom of the bore, puts the fuze—if a paper one—into the fuze plug, inserts the hooks into the ears of the shell, raises it about a foot from the ground, and holds it while No. 2 wipes it, and then places it in the bore. No. 2 replaces the wiper upon the stake, lays the slack of the pointing cord over the left manœuvring-bolts, and resumes his post. At the command POINT, Nos. 1 and 2 embar under either the front or rear notches, as required. At the signal from the gunner, No. 1 prepares to fire the piece as prescribed for No. 3 in par. 45.

SERVICE OF A COEHORN MORTAR.

50. *Same number* of men are necessary as for the service of the 8-inch siege mortar. The implements, etc., and their arrangement, are the same as prescribed for that mortar except that there is no elevating-bar. Instruction also the same. To prepare its ammunition, and to transport it by hand, *two additional* men are required. The gunner carries the basket and implements.

SERVICE OF 13-INCH SEA-COAST MORTAR MOUNTED ON BED WITH ECCENTRIC AXLE.

The detachment consists of *six* men and a gunner.

51. The implements are arranged as follows:

Two truck-handspikes (Iron.)	Hung on hooks on the cheeks.
Two manœuvring-handspikes. (Wooden, shod with Iron.)	Laid on platform against the cheeks, small ends resting on the truck wheels.
Elevating-bar (Iron.)	Laid across the cheeks over the rear notches, handle to the left.
Sponge.	On prop, 1 yd. in rear of No. 1, sponge head toward epaulment.
Shell-hooks. *Pointing-cord.* *Quadrant.* *Scraper, &c., &c.*	As prescribed in paragraph 40.

To the same battery, there should be one *hammer-wrench.*

To cause the pointing-stakes to be established in position.

The instructor commands:

PLANT THE POINTING-STAKES.

52. Executed as in par. 41.

To cause the implements to be distributed.

The instructor commands:

TAKE IMPLEMENTS.

The implements are distributed as in paragraph 42, except that the iron handspikes are habitually hung on

the hooks when not in use, and that No. 6 removes the elevating-bar. The wooden handspikes are laid on the ground perpendicular to the cheeks, opposite to Nos. 1 and 2, the small ends resting on the edge of the platform.

To cause the service of the piece to be executed.

The instructor commands:

IN BATTERY.

53. The gunner steps two yards in the rear of the platform, facing to the front, and giving the command IN GEAR. Nos. 3 and 4 take the truck handspikes from the hooks, and embar in the eccentric sockets. Nos. 5 and 6 seize the handspikes *above* the hands of Nos. 3 and 4.

The gunner gives the command HEAVE, and as soon as the wheels are in gear, the command EMBAR, when the handspikes are placed in the most convenient rear mortices of the truck wheels. The mortar is moved to the front as far as required, by the alternate commands HEAVE and EMBAR, from the gunner, Nos. 3, 4, 5, and 6 facing to the front.

At the command HALT, given by the gunner, he immediately gives the command OUT OF GEAR, and the handspikes are again inserted in the eccentric sockets and at the command HEAVE, the wheels thrown out of gear, Nos. 3, 4, 5 and 6 then resume their posts.

FROM BATTERY.

Executed as above, except that the truck handspikes are inserted in the most convenient front mortices of the truck wheels after the wheels are in gear, Nos. 3, 4, 5 and 6 facing to the rear.

2. *Load by detail*—LOAD.

53. The gunner steps in front of the muzzle, scraping the bore only when too foul to be cleaned by the sponge. No. 1 faces to his right, seizes the sponge staff in his right hand, mounts upon the step and pushes the sponge to the bottom of the bore, sponges with both hands, and returns to his post, replacing the sponge on the prop, and taking the wiper. No. 4 goes for the cartridge, Nos. 2, 3, 5 and 6 go for the shell, No. 2 carrying his truck handspike in his left hand and the shell-hooks in his right hand. No. 2 puts the shell-hooks in the ears of the shell and passes his handspike through the ring. In carrying the shell, Nos. 2 and 3 are in advance, Nos. 5 and 6 in rear, the hands of the even numbers at the ends of the handspike, Nos. 2 and 6 using their left hands, and Nos. 3 and 5 their right. Passing by the left of the piece between the gunner and the muzzle, the shell is rested on the step and wiped by No. 1, who then resumes his post. No. 4 passes the cartridge to the gunner, who distributes the powder evenly over the bottom of the bore and returns the cartridge bag to No. 4, who then stretches the pointing-cord by the left of the mortar to the rear pointing-stake, and resumes his post. The shell is raised from the step and lowered into the bore until the bar rests against the face of the mortar. The gunner seizes the shell-hooks, and after No. 2 withdraws the handspike, lowers the shell into its place, removes the shell-hooks and passes them to No. 2. After the shell is lowered, No. 2 replaces the shell-hooks and handspike and with the other numbers and the gunner, resumes his post.

When necessary, the platform will be swept by No. 1.

3. Point.

54. The gunner places himself behind the rear pointing-stake, and holding the pointing-cord in the left hand and the plummet in the right, gives the *direction*, commanding, Muzzle Right, Muzzle Left, Mortar Right, Mortar Left, according to circumstances.

To throw the muzzle to the right. At this command, the wheels are thrown in gear as described above. The handspikes are then inserted in the truck mortices, and at the command Heave from the gunner, Nos. 3 and 5 heave to the rear, and Nos. 4 and 6 to the front.

To throw the muzzle to the left. Same as above, except that Nos. 3 and 5 heave to the front, and Nos. 4 and 6 to the rear.

To throw the mortar to the right (or left). This may be executed by giving the muzzle the proper direction and running the mortar in battery, or by giving the muzzle the contrary direction and running the mortar from battery. In either case the manœuvre is completed by throwing the muzzle in the contrary direction. The mortar may be given any direction on its platform by the commands already given.

The direction having been given, the eccentrics are thrown out of gear. If necessary to give more exact direction to the mortar after the eccentrics are thrown out of gear, Nos. 1 and 2, assisted by Nos. 3 and 4, embar under the front (or rear) notches with the wooden handspike to move the muzzle (or trail.)

No. 3 then prepares the lanyard and primer, and the elevation is given by the gunner, who applies the quadrant to the face of the piece, and directs No. 6, assisted by No. 5, to Raise or Lower with the elevating-bar.

The *elevation* having been given, the gunner gives the command READY. No. 6 lays the elevating-bar behind his post and parallel to the wooden handspikes. The gunner places the plummet at the rear stake, returns the pointing cord to the foot of the epaulment, receives the lanyard and primer from No. 3 and passing it under the pipe inserts the primer in the vent, and goes where he can best observe the effect of the shot. The rest of the cannoneers, except No. 3, retire four yards in rear of the platform and form detachments, as in "detachment rear," leaving No. 4 uncovered. No. 3 holding the handle of the lanyard in his right hand, moves three yards to the rear in the prolongation of the right cheek, and facing to the left of the battery breaks to the rear one yard with his left foot, turning his face away from the piece.

4. *Number one* (or the like)—FIRE.

55. Executed as in paragraph 45, except when more than one mortar is being fired, in which case No. 3 joins his detachment and the cannoneers resume their posts at the command or signal from the officer in command.

REMARKS.—It sometimes happens that when the wheels are thrown out of gear after pointing, the mortar bed moves forward sufficiently to change materially the direction.

The evil may be nearly or quite corrected by firmly chocking the truck wheels before throwing them out of gear.

If in securing the mortar the muzzle has been so far depressed that the elevating bar cannot be engaged in the ratchets, a trace chain may be doubled over the ratchet and the bar engaged in the bight of the chain, or the elevating bar may be placed in the ratchets perpendicular to the axis of the piece, and then the wooden handspikes engaged over the bar and under the nuts or T plates of the cheeks and the mortar thus be elevated.

SERVICE OF 10-INCH SEA-COAST MORTAR ON IRON BED WITH ECCENTRIC AXLE.

56. The detachment consists of *four* men and a gunner.

The implements are the same as for the 13-inch mortar, except that there is no sponge. They are distributed as in serving the 10-inch siege mortar par. 42, except when there are no hooks on the cheeks, the truck-handspikes are laid on the platform in front of Nos. 1 and 2, parallel to the cheeks, small ends to the front, and are retained in this position whenever not actually in use.

The mortar is manœuvred on its platform as prescribed in the manual for the 13-inch mortar, and by the same commands.

The loading is conducted as prescribed for the service of the 10-inch siege mortar par. 43.

SERVICE OF A 13-INCH SEA-COAST MORTAR MOUNTED ON A CENTRE PINTLE CARRIAGE.

57. The detachment consists of a chief of piece, one gunner and six other cannoneers.

Implements.

The implements are arranged as follows :

Four truck handspikes (*Iron.*)	On the hooks on chassis rails.

Two elevating-bars.	On the hooks on the cheeks.
Two wheel chocks.	On the hurters.
Blocks and fall (Rove.)	Attached to crane.
Sponge.	On prop, one yard in rear of No. 1, head towards epaulment.
Shell-hooks, Scraper, Wiper, Quadrant, Cartridge-pouch, Pointing stakes, Pointing-cord, Primer-pouch, Gunner's-pouch, Maul, Bro m, and Plummet, Carrying-bar.	In or near basket in front of the chassis.

Posts of the cannoneers.

58. The detachment for serving the piece is formed and numbered as in the service of the piece without the chassis. It is marched to the battery by the flank, halted and faced to the front opposite to and two yards from the rear of the chassis.

The cannoneers at their posts are arranged as follows: Nos. 1 and 2 eighteen inches from and opposite the front ends of the chassis rails. The others dressing on Nos. 1 and 2 at intervals of one yard except, that between Nos. 3 and 5 there is an interval of two yards. The chief of piece assists the instructor, and at the battery will generally be one yard outside the cannoneers of the left, facing the piece, and two yards in rear of the chassis.

Planting the pointing-stakes.

59. The gunner will be charged with the pointing

Nos. 1 and 2 will assist in any method requiring it in front of the mortar, and Nos. 5 and 6 in rear. One or all, as may be necessary.

The method here proposed is assimilated to the one now in use with the piece otherwise mounted. It requires in addition to the implements now provided, some method for suspending the plummet so as to avoid the wavering incidental to holding it by the hand unaided.

To cause the pointing-stakes to be established in position, the instructor commands :

Plant the Pointing-stakes.

The gunner, assisted by Nos. 1 and 6, determines the plane of fire. No. 1 mounts the parapet with stake and maul. No. 6 sees that the plummet swings directly on the centre of the pintle. The gunner from the rear of the plummet locates the stake of No. 1 in the vertical plane passing through the plummet line and a vertical line through the object. The stake is driven in the interior crest by No. 1.

It may be found necessary to resort to some device to give the gunner elevation enough to see the object to be attained from his position behind the plummet-line. The stake established, No. 1 drives another one yard behind his post for holding the wiper, and replaces the maul near the basket. The gunner attaches the pointing-cord to the stake in the crest and lays the slack at the foot of the epaulment.

To fire at an object invisible from the mortar, the position of the stake in the crest is determined on the principle of the interpolation of points on a line connecting two objects invisible from each other. The stakes on

the parapet used to determine the situation of the interpolated points, may be handled separately by Nos. 1 and 2, or both the stakes may be permanently attached to a horizontal bar and handled by No. 1 under the direction of the gunner.

Distribution of implements

To cause the implements to be distributed the instructor commands :

TAKE IMPLEMENTS.

60. The implements are distributed as in paragraph 41, except that the handspikes are habitually on the hooks when not in use.

Service of the Piece.

The piece will be habitually in battery while being loaded.
The instructor causes the service of the piece to be executed by the following commands :

1. IN BATTERY, OR FROM BATTERY.

61. Executed as laid down for the service of the piece when resting on its platform, except that in running the piece from battery Nos. 1 and 2 follow up the movement and keep the wheel-chocks closely applied to the wheels.

2. *Load by Detail*—LOAD.

Executed as laid down for the service of the piece

when resting on its platform, with the following exceptions. The shell is brought up on the side of the crane, lowered to the platform, carrying-bar withdrawn, and the pulley attached to the shell-hooks by No. 3. The crane is unkeyed and swung into a plane perpendicular to the top carriage by No. 2. Nos. 3 and 5 run up the projectile, No. 2 steadying it. When sufficiently raised it is wiped by No. 1, swung over the bore and lowered to its place under the direction of the gunner.

3. POINT.

62. The gunner commands; 1. CHASSIS IN GEAR. 2. HEAVE. Nos. 1 and 2, with the handspike of No. 2, embar in the socket of the front eccentric, No. 1 first seeing that the axle is unlocked. Nos. 5 and 6 embar in the sockets of the rear eccentrics. The chassis being in gear and the front eccentric locked by No. 1, No. 2 then inserts his handspike in the uppermost mortices of the front traverse wheel, No. 1 still assisting. The gunner, assisted by No. 6, as in establishing the plane of fire, brings the line of metal into this plane by the commands MUZZLE RIGHT, MUZZLE LEFT. Should the chassis traverse with difficulty, Nos 1 and 2 can separately embar, each in a mortice on his own side.

The direction being given, the gunner commands: 1. CHASSIS OUT OF GEAR. 2. HEAVE. The front axle is unlocked by No. 1 and both eccentrics thrown out of gear. No. 1 then double locks the front axle by pawl and toggle. The handspikes are withdrawn and placed on the hooks.

No. 3 prepares the friction-primer and lanyard. The gunner, assisted by Nos. 5 and 6, gives the elevation, commands READY, receives the friction-primer and lanyard

from No. 3 and inserts the primer. The detachment is then marched to the rear as before described in the service of the piece on its platform.

4. *Number one* (or the like)—FIRE.

Executed as in the service of the piece on its platform, par. 54.

ON POINTING.

With the mortar mounted on a centre-pintle carriage, the vertical plane of fire must always contain the vertical axis of the pintle, it follows then, in pointing, that the prolongation of this axis must be one of the lines determining the position of this plane. A second line will be a vertical one passing through the object to be reached. The line of metal will also be a line of this plane. Great accuracy, therefore, is required in the establishment of the pointing-stakes or other device for practically fixing this plane. The point in the interior crest opposite the centre of the platform can no longer be invariably taken as the initial point for determining the intersection of the plane of fire with the superior slope. Instead, the centre of the pintle or a point on the line of metal must be taken. It is important that the one giving the direction shall see the object aimed at.

SERVICE OF A 10-INCH RODMAN SMOOTH-BORE OR 8-IN. RIFLE GUN MOUNTED ON AN IRON CARRIAGE.

Seven men are necessary—one gunner and six cannoneers.

The piece is in battery.

63. The implements and equipments are arranged as follows:

Four truck-handspikes, (Iron.)	Two on each side of the carriage, placed on their hooks.
Elevating-bar . . . (Iron.)	To be laid on the carriage over the rear notches and perpendicular to the piece, handle to the left.
Sponge, rammer . .	One yard behind the cannoneers of the right, the sponge uppermost; the sponge and rammer-heads turned from the parapet, inclined slightly from the piece, and supported upon a prop.
Pass-box	Against the parapet, outside of No. 2.
Primer-pouch . . .	Containing friction-primers, and the lanyard wound in St. Andrew's cross upon its handle. Suspended from the ratchet-post.
Gunner's-pouch. . .	Containing breech-sight, finger-stall, priming-wire, gunner's gimlet, and vent-punch. When the breech-sight has no fixed seat, there will be added a gunner's level, chalk-line, and chalk. Suspended from ratchet-post.

Chocks	One on each hurter.
Vent-cover	Covering the vent.
Tompion	In the muzzle.
Broom	Leaning against the parapet, to left of the piece.
Budge-barrel	Containing cartridges; at the safest and most convenient place in rear of the piece.

When several pieces are served together there will be one gunner's level, one worm, one wrench, and two vent-punches to each battery of not exceeding six pieces.

The shells are at the magazine, or other safe position, and are brought as required to the place prescribed for the budge-barrel.

The cannoneers having been marched to their posts, the instructor explains to them the names and the uses of the implements, and nomenclature of the piece, its carriage, and the battery.

To cause the equipments to be distributed, the instructor commands:

TAKE EQUIPMENTS.

64. The gunner mounts upon the chassis, takes off the vent-cover, hands it to No. 2 to place against the parapet in rear of his post; gives the primer-pouch to No. 3; equips himself with his own pouch and finger-stall, wearing the latter on the second finger of the left hand; levels the piece conveniently for loading, and resumes his post.

No. 3 equips himself with the primer-pouch.

The handspikes when not in use will remain on the hooks.

The instructor causes the service of the piece to be executed by the following commands:

1. From Battery.

65. The gunner moves two yards in rear of the chassis and commands In gear. Nos. 3 and 4 take their handspikes from the hooks, embar in the eccentric sockets, and assisted by Nos. 5 and 6, throw the wheels in gear at the command Heave from the gunner. The gunner then commands Embar, Nos. 3 and 4 then withdraw their handspikes and insert them in the most convenient mortices of the truck wheels, Nos. 5 and 6 seize the handspikes with both hands above the hands of Nos. 3 and 4, all breaking to the rear with the foot nearest the carriage. The gunner then gives the command Heave, Nos. 3, 4, 5, and 6 acting together, bear down upon the handspikes until they are nearly down to the rails; Nos. 1 and 2 follow up with the chocks. The gunner commands Embar. Nos. 5 and 6 let go the handspikes, Nos. 3 and 4 withdraw them and embar as before. The gunner gives the command Heave, which will be executed as before. The commands Embar and Heave, will be repeated by the gunner until the face of the piece is about one yard from the parapet, when the gunner commands Halt, Out of gear. Nos. 1 and 2 chock the wheels; Nos. 3 and 4 withdraw their handspikes, insert them in the eccentric sockets, and at the command Heave, throw the wheels out of gear, leaving the handspikes in the sockets. All resume their posts.

2. *Load by detail*—Load.

66. Executed as in siege-gun, par. 13, with the following modifications: No. 3 does not embar under the breech, but leaves his handspike in the socket as prescribed above, and as soon as the sponge is inserted in the

bore, steps over the rammer, and seizing the staff in the prescribed manner, returns to his post and stands ready to exchange with No. 1. The gunner mounts upon the chassis and stops the vent. Nos. 1 and 2 place the feet nearest the carriage on the rails of the chassis in line with the face of the piece; the other feet are in the most convenient position on the parapet. The execution of the remainder is the same as in the case of siege-gun, No. 13.

Nos. 5 and 6 bring up the shell.

3. SPONGE.

67. Executed as in siege-gun, par. 14.

4. RAM.

68. Executed as in siege-gun, par. 15, except that the shell is set carefully home without being rammed. With large rifle shells, No. 5 holding the fuze end and No. 6 the butt, pass to the left of the piece, and stopping between the parapet and the face, No. 2 receives the butt of the projectile from No. 6, and assisted by Nos. 1 and 5, inserts it in the muzzle. Nos. 5 and 6 resume their posts. Spherical shells are loaded as follows:

No. 6 takes the handspike and goes for the shell, followed by No. 5. He passes the small end of the handspike through the ring of the shell-hooks, or through the loop of the rope handle; No. 5 holds the small end of the handspike with his right hand, No. 6 the butt end, No. 5 in front. They bring it up on the left of the piece, and place themselves parallel to the parapet, No. 5 behind No. 2. No. 5 stepping between the parapet and the face of the piece, passes his end of the handspike to No 1, and

places himself on the platform, beneath the muzzle; No. 6 gives his end of the hands ike to No. 2. Nos. 1 and 2 raise the shell until it is opposite the muzzle, when No. 5, applying his hands under it. raises the sabot and inserts it in the muzzle. No. 2 withdraws the handspike and pass s it to No. 6, who replaces it. No. 5 pushes the shell into the muzzle, and returns to his post.

Before running the piece into battery, it should be elevated at least 2 degrees, to prevent the dis; lacement of the projectile. With all rifle projectiles with expanding bases, No. 6, after receiving it, must wipe the base of the projectile clean before inserting it into the muzzle.

5. In Battery.

69. The gunner gives the command In Gear. Nos. 1 and 2 unchock the wheels and place the chocks on the hurters, Nos. 3 and 4 seize the handspikes and at the command Heave from the gunner, bear down slowly until the piece is in motion, regulating it by alternately throwing the wheels in and out of gear or partially so. As soon as the carriage strikes the hurters the gunner commands Out of gear, Heave. Nos. 3 and 4 throw the wheels out of gear, withdraw their hands; ikes, replace them on the hooks, and resume their posts. Should the carriage not move when in gear, the gunner will direct No. 3 to insert his handspike in the mortice of the truck wheel and urge it forward, slightly engaging his handspike from the rear.

6. Point.

70. The gunner commands 1. Chassis in gear, 2. heave. At the first command Nos. 3 and 4 embar

from the rear in the sockets of the eccentric, and at the second command, assisted by Nos. 1 and 2, they throw the chassis wheels in gear and resume their posts, leaving the handspikes in the sockets. Nos. 5 and 6 embar in the rear traverse wheels. The gunner withdraws the priming wire, adjusts the breech sight, and gives the direction, commanding LEFT or RIGHT, tapping at the same time on the right side of the breech to move the chassis to the left, or on the left to move it to the right, (when necessary Nos. 5 and 6 are assisted by Nos. 1 and 2.

When the direction is given the gunner commands 1. CHASSIS OUT OF GEAR, 2. HEAVE. At the first command Nos. 1 and 2 seize the handspikes, and at the second command throw the wheels out of gear, replace the handspikes, and resume their posts.

No. 3 passes the hook of the lanyard through the eye of a primer, holds the handle of the lanyard with the right hand, the hook between the thumb and forefinger, and stands ready to hand it to the gunner. No. 4 mounts upon the chassis, and embarring through the ratchet-post with the elevating-bar, raises and lowers the breech as directed by the gunner. When the piece is correctly pointed the gunner commands READY, makes a signal with both hands, takes the breech sight with his left hand, and receiving the tube from No. 3 in his right, inserts it in the vent, dismounts from the chassis and goes where he can best observe the effect of the shot. Nos. 1 and 2 lock the axle and break to the rear with the foot farthest from the epaulment. No. 3 drops the handle, allowing the lanyard to pass through his fingers, steps back obliquely three yards to the rear and breaks off with the left foot, turning his face from the piece, left hand against the thigh. Nos. 5 and 6 unbar, and with No. 4 resume their posts.

7. *Number one* (or the like)—FIRE.

Executed as in siege-gun, par. 18.

With the centre-pintle carriage in pointing, Nos. 1 and 2 facing to the rear, embar with their handspikes under the front traverse wheels. The handspikes of Nos. 1 and 2, when not in use, are placed against the parapet near them. If there are mortices in the front traverse wheels, Nos. 1 and 2 will insert the truck handspikes in them to give the direction. The piece is *secured* and *implements replaced* in the usual manner.

SERVICE OF A 15-INCH GUN MOUNTED ON A CENTRE-PINTLE CARRIAGE, WITH AIR-CYLINDERS.

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71. IMPLEMENTS AND EQUIPMENTS.

Two front Handspikes. (Iron.)	Fixed to the front eccentric sockets by set screws. Ropes are attached to the small end of these handspikes for use in manœuvring the gun. When not in use the ropes are hung up on the hooks on the cheeks of the carriage. Eyes are let into the ropes for this purpose.

Four Truck-Handspikes. (Iron.)	On the hooks on chassis rails. On some carriages there are two additional handspikes, fixed to the eccentric sockets of the rear truck wheels by set screws. These are of wood and iron combined in order to secure lightness with the requisite strength.
One Elevating-Bar.	Laid on the carriage, over the rear notches and perpendicular to the piece, handle to the left.
Sponge and Rammer.	One yard behind the cannoneers of the right — the sponge uppermost, the sponge and rammer-heads turned from the parapet, inclined slightly from the piece and supported on a prop, or placed against the wall, the sponge and rammer-heads nearest the piece when there is no prop.
Pass-Box.	Two yards in rear of No. 7. If possible under cover.
Primer-Pouch.	Containing friction-primers, and the lanyard wound in St. Andrew's cross upon its handle, hung on the step of the ratchet-post.

Gunner's-Pouch.	Containing finger-stall, priming wire, gimlet and vent punch, (when there are no fixed sights a gunner's level, chalk line and chalk will be added) also hanging on the step of the ratchet-post.
Chocks.	One on each hurter, or pivoted on the cheeks of the carriage.
Vent-cover.	Covering the vent.
Tompion.	In the muzzle.
Broom.	Leaning against the parapet. to the left of the piece.
Carrying-bar.	On the left of the piece near No. 10.
Shell-hooks.	On the left of the piece, near No. 4.
Differential Pulley or Fall.	Attached to the crane.

With the air-cylinder carriage, neither the handspikes, elevating-bar nor equipments will ever be placed on the floor-boards, there not being sufficient space between the floor-boards and rear transom of the top carriage when the latter comes from battery. If the chassis has no hooks for the handspikes they will be laid on the

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platform in front of the cannoneers and parallel to the carriage.

The cannoneers take implements as hereinafter provided, and return them to their places whenever they are not actually in use.

The detachment consists of eleven men including the gunner.

The gun is in battery, the cannoneers at their posts, as in par. 58.

To distribute the equipments the instructor commands:

TAKE EQUIPMENTS.

72. The gunner steps on the chassis, takes off the vent-cover, hands it to No. 6 to place against the parapet in rear of his post; gives the primer-pouch to No. 3 and equips himself with his own pouch and finger-stall, wearing the latter on the second finger of the left hand; Nos. 1 and 2 remove the plugs from the air-cylinders; No. 3 equips himself with the primer-pouch; No. 5 and 6 hook the ropes on to the handspikes of the front axle if they are not permanently attached thereto and step upon the chassis. Under the direction of the gunner No. 6 takes the elevating-bar, embars with it through the ratchet-post, and, assisted by No. 5, levels the piece conveniently for loading, replaces the elevating-bar, and with No. 5 resumes his post. The gunner, if necessary, applies his level to verify the line of sight which is marked on the piece, marking it if desired, assisted by No. 2, and both resume their posts.

To serve the piece the instructor gives the following commands:

1. From Battery.

73. The gunner commands IN GEAR, and mounts upon the chassis to superintend the movement; Nos. 3 and 4 observe that the handspike-pawls are clear of the ratchets of the truck wheels and raise the handspikes while Nos. 5 and 6 take down the ropes. Nos. 3 to 8 inclusive, seize the front handspikes; Nos. 9 and 10, mounting the steps, unlock the axle, seize the rear handspikes and, assisted if necessary, by Nos. 7 and 8, throw the wheels in gear, at the command HEAVE from the gunner.

The gunner then commands EMBAR, and the front handspikes are raised until Nos. 3 and 4 are able to engage the handspike-pawls in the most convenient ratchets of the truck-wheels. The piece is now run from battery by the alternate commands HEAVE and EMBAR from the gunner, all the cannoneers from 3 to 10 inclusive assisting at the front handspikes. Nos. 1 and 2 follow up the movement and keep the wheel-chocks closely applied to the wheels; Nos. 3 and 4 engage the pawls in the ratchets whenever the handspikes are raised. The piece being in the proper position for loading, the gunner commands HALT, OUT OF GEAR, HEAVE. Nos. 9 and 10 unlock the axle and throw the wheels out of gear, leaving the handspikes in the sockets. Nos. 3 and 4 clear the handspike-pawls and raise the handspikes, while Nos. 5 and 6 secure the ropes. All the cannoneers except the gunner resume their posts.

2. *Load by Detail*—LOAD

74. Nos. 1 and 2 step upon the front of the chassis or on the steps in the breast-height wall; No. 2 removes the

tompion and hands it to No. 4 who places it against the breast-height and four yards in his rear. No. 3 brings up the sponge, passes it to No. 1 and mounts upon the chassis or steps of the breast-height to assist Nos. 1 and 2 in sponging; the sponge-head is caught in the muzzle, No. 5 stands ready to take the sponge from No. 3 ; Nos. 7 and 9, taking the pass-box, go for the cartridge. Nos. 4, 6, 8 and 10 go for the projectile ; No. 4 carrying the shell-hooks and No. 10 the carrying-bar. In returning, the cartridge is brought up on the right of the piece, and the projectile on the left, No. 4 in advance, No. 10 in rear. The projectile is placed under the crane, the carrying-bar replaced by No. 10 and the pulley attached to the shell-hooks by No. 4 ; Nos. 6 and 8 run up the projectile, No. 4 steadying it; No. 10 resumes his post.

The gunner stops the vent ; and Nos. 1 and 2 assisted by No. 3, whose position is outside of that of No. 1, insert the sponge by motions, at the words from the instructor ONE, TWO, THREE, FOUR, FIVE, as follows :

1st MOTION :—Insert the sponge as far as the hand of No. 1, bodies erect, shoulders square.

2nd MOTION :—Slide the hands along the staff and seize it at arms length.

3rd MOTION :—Force the sponge down as prescribed in first motion.

4th MOTION :—Repeat the second motion.

5th MOTION :—Push the sponge to the bottom of the bore.

No. 1 places the left hand on the staff, back up, six inches nearer to the muzzle than the right ; No. 2 places

the right hand, back, up, between the hands of No. 1. If in executing these motions or the corresponding ones with the rammer, it be found that the sponge or rammer cannot be sent home in five motions, then what is prescribed for the fourth and fifth will be performed in a sixth and seventh motion. The knee on the side toward which the body is to be inclined is always bent, the other straightened and the weight of the body added as much as possible to the effort exerted by the arms.

3. Sponge.

75. Nos. 1, 2 and 3 pressing the sponge firmly against the bottom of the bore, turn it three times from right to left and three from left to right, replace the hands on the thighs, and withdraw the sponge, at the words ONE, TWO, THREE, FOUR, FIVE from the instructor, by motions contrary to those prescribed for inserting it. As soon as the sponge is withdrawn, No. 3 turning toward the left passes the sponge with both hands behind No. 1 to No. 5, who replaces it upon its prop; Nos. 1 and 2 then receive the cartridge from Nos. 7 and 9, and insert it in the bore bottom foremost, seams to the sides, choke to the front; Nos. 7 and 9 replace the pass-box and resume their posts; No. 5 picks up the rammer and passes it to No. 3 behind No. 1, and resumes his post; No. 3 receives the rammer, and as soon as the cartridge is inserted, places the rammer-head in the bore. The cartridge is forced down by Nos. 1, 2 and 3 by the commands and motions prescribed for the sponge.

4. Ram.

76. The cartridge is set home by strong pressure, not

by a blow. Nos. 1 and 3 throw out the rammer, No. 2 quitting the staff to assist No. 4 in swinging the crane round to bring the projectile in fr nt of the muzzle; the rammer-head is placed against the projectile, which is pushed into the bore by Nos. 1, 2, 3 and 4; No. 4 then withdraws the shell-hooks, and resumes his post; the remaining numbers force the projectile home by motions and commands as before. Nos. 6 and 8 swing the crane back, and, if it is attached to the top carriage secure it and the pulley against the cheek and resume their posts. The rammer is thrown out and passed by No. 3 to No. 5, who places it on the prop; Nos. 1, 2, 3 and 5 then resume their posts. The gunner gives the piece an elevation of at least two degrees as soon as the projectile is inserted, and when it is home, pricks the cartridge and leaves the priming-wire in the vent.

5. In Battery.

77. The gunner commands In Gear. Nos. 1 and 2 unchock the wheels; Nos. 3 and 4 see that the handspike-pawls are clear of the ratchets; Nos. 9 and 10 mount upon the steps, unlock the axle, seize the rear handspikes and, at the command Heave by the gunner, bear down slowly, assisted if necessary by Nos 7 and 8, until the piece is in motion, and regulate it by alternately throwing the wheels in and out of gear sufficiently for the purpose. The front wheels are not chocked by Nos. 1 and 2 unless the gunner so directs. As soon as the carriage strikes the hurter the gunner commands Out of Gear, Heave. Nos. 9 and 10 throw the wheels out of gear and secure the axle with the pawl; all resume their posts.

Should the carriage not move when the wheels are

thrown in gear, the gunner will direct Nos. 3, 4, 5 and 6 to lower the handspike and engage the upper arm of the handspike-pawl in the ratchet and by raising the handspike urge the piece forward.

6. Point.

78. The gunner commands: 1. Chassis in gear. 2. Heave. Nos. 7 and 8 take the handspikes, embar in the sockets of the eccentrics of the chassis, and assisted by Nos. 9 and 10 throw the wheels in gear; they then embar with the same handspikes in the mortices of the rear set of the front traverse wheels; Nos. 1 a d 2 embar in the set nearest the parapet; Nos. 5 and 6 mount on the chassis to assist the gunner. in giving the elevation; No. 3 passes the hook of the lanyard through the eye of a primer from front to rear and stands ready to hand it to the gunner. The gun is traversed by Nos. 1, 2, 7 and 8 at the commands Muzzle right or Muzzle left, given by the gunner. The directi n being given, the gunner commands: 1. Chassis out of gear. 2. Heave. At the first command Nos. 1 and 2 return their handspikes to their places and resume their posts; Nos. 7 and 8 embar in the sockets of the eccentrics of the chassis, and assisted by Nos. 9 and 10, at the second command throw the chassis out of gear; Nos. 7 and 8 then replace their handspikes and, with Nos. 9 and 10, resume their posts. The gunner then causes No. 6, assisted if necessary by No. 5, to give the required elevation to the piece, and commands Ready; Nos. 5 and 6 resume their posts, No. 6 taking the elevating-bar which he places on the platform. The gunner removes the priming wire, receives the friction-primer from No. 3, inserts it in the vent, takes the breech-sight in his left hand and

goes where he can best observe the effect of the shot. The chief of piece then commands: 1. DETACHMENT REAR, 2. MARCH. At the first command the cannoneers, except No. 3, face from the epaulment: at the second command they march to the rear, the cannoneers of the left closing on those of the right. The detachment files to the right and is halted and faced to the front by the chief of piece so as to bring the centre opposite to the middle of the chassis, and four yards from it. The chief of piece places himself on the right. No. 3 drops the handle allowing the lanyard to pass through his fingers and steps back three yards obliquely to the rear, breaks off with his left foot, turning his face from the piece, the left hand against the thigh.

7. FIRE.

No. 3 discharges the piece by a strong and steady pull of the lanyard. The cannoneers will resume their posts at the command from the chief of piece: 1. CANNONEERS TO YOUR POSTS. 2. MARCH; the gunner giving the commands required in par. 6 to be given by the chief of piece.

To secure the piece and replace equipments.

79. The instructor first causes the piece to be run into battery by the command IN BATTERY already mentioned. He then commands:

1. SECURE PIECE.

At which No. 4 passes the tompion to No. 2 who returns it to the muzzle; Nos. 1 and 2 replace the plugs in the air-cylinders; the gunner then puts on the vent-cover, which he receives from No. 6, and with the assistance of

Nos. 5 and 6, depresses the piece in the general mode required in taking equipments.

2. REPLACE EQUIPMENTS.

The gunner then hangs the pouches on the steps of the ratchet-post.

THE SERVICE OF A 15-INCH GUN ON FRONT PINTLE CARRIAGE (WITH AIR CYLINDERS).

80. The drill is the same as that for the centre-pintle carriage except as follows, viz:

1st. After what is prescribed under the head RAM has been completed, the gunner commands: 1. CHASSIS IN GEAR. 2. HEAVE. At the first command Nos. 3 and 4 embar with the handspikes in the most convenient sockets of the chassis eccentrics, and at the second command, assisted by Nos. 1, 2, 7, and 8, throw the wheels in gear.

2nd. At the command POINT, the direction is given (under the direction of the gunner) by Nos. 7, 8, 9, and 10, who man the cranks of the geared traverse wheels. At the command 1. CHASSIS OUT OF GEAR. 2. HEAVE, the chassis is thrown out of gear by Nos. 1, 2, 3, 4, 7, and 8, Nos. 3 and 4 embarring with the handspikes.

GENERAL REMARKS.

81. In these carriages the front eccentric axle is re

placed by an ordinary one, dispensing with axle-pawls and friction-bands, the handspike-pawls are made double instead of single, with a spring to keep them out of the ratchets, the front set of transoms and diagonal braces are removed from the chassis and air-cylinders put in with thick braces.

The front axle arms are furnished with brass sleeves firmly attached. Each front eccentric socket is terminated by a heavy casting called the counterpoise, which is fitted by a collar to revolve freely upon its axle-sleeve without communicating any motion to the axle; the handspike-socket and counterpoise form virtually one piece.

To prevent the wheels from working out of gear while the gun is being run from battery, or jumping in gear when the gun is fired, pawls are provided for locking the rear axle. Motion is communicated to the carriage through the truck wheels by means of pawls attached to the front handspikes and working in the ratchets of the truck wheels. The handspike-pawls are only engaged in the ratchets of the truck wheels when it is desired to give motion to the carriage; at all other times they must be kept clear of the ratchets.

For hoisting projectiles to the muzzle two kinds of cranes are in process of trial, one of them attached to the chassis, the other to the top carriage. The former is the one referred to in this drill.

The direction is given to the piece by means of a rear sight and a trunnion sight. The former is screwed to the piece at the highest point of the breech, and is used solely in giving the direction. There are no degrees marked on it. The trunnion sight is screwed to the highest point of the piece between the trunnions. The elevation is given by means of a brass elevating arc attached to the breech

of the gun at the side of and parallel with the ratchet. An index or pointer is attached to the ratchet-post and the elevation is given by raising or lowering the breech of the piece until the required degree on the elevating arc corresponds with the index.

When no pawls are provided for locking the axles, it is often necessary for one cannoneer at each axle to remain embarred in the eccentric sockets to prevent the axles from flying out of gear.

The crane attached to the top carriage will take up a shot in any position near the platform on the side to which it is attached, and the gun can be loaded in any position on the chassis. The differential pulley will be used, but a light fall, rove through double and single blocks, may often answer. If the crane is on the right of the piece, No. 3 performs the duties assigned to No. 4, No. 5 those of No. 6, etc., etc. The sponge and rammer should then be on the left of the piece, the cartridge being also brought up on the left by Nos. 8 and 10.

Paixhan's apparatus for lifting the shot to the muzzle, as sometimes applied, is constructed as follows: An extra transom is bolted to the chassis rails in front of the front transom as a support for a ratchet-bar, which is raised or lowered in a jacket by a pinion worked by two small crank handles. A shot-ladle is attached to the head of the ratchet-bar. An inclined plane or trough, leads from the shot pile to the ladle, delivering the shot just below the interior crest. The trough is horizontal for a few feet from the muzzle, so that several shot may be kept in the immediate vicinity of the ladle. To use this apparatus, the trough being on the left of the piece, the shot are rolled up the incline by Nos. 8 and 10. At the command LOAD, No 6 steps over the chassis, just behind the front

transom, faces towards the parapet, adjusts the ladle to receive the shot, and assists No. 4 in placing the shot on the ladle. As soon as No. 7 has delivered the cartridge, he takes a position corresponding to that of No. 6, and assists to run up the shot to the muzzle the instant the rammer is withdrawn, after setting home the cartridge. The shot is inserted in the muzzle by Nos. 1, 2, and 3. If the trough is on the right of the gun, the changes in the duties of the numbers, as indicated above for the crane, must be made. In rolling a shot up the trough, great care must be taken to avoid breaking the sabot. The shell should be placed in the ladle, the sabot to the rear. No. 4 will assist in inserting it in the muzzle.

The carriage permits an elevation of about 32 degrees, and a depression of about 6 degrees, unless when fitted with air cylinders, when no more than 25 degrees elevation can be given.

The shell cannot be safely fired with a charge greater than two-thirds that for solid shot.

When air cylinders are not attached to the chassis, it is very essential to sand the rails before the gun is fired. If the piece is from battery, sand the rails in front, then run the carriage in battery and sand the rails in rear. If the piece is in battery and the rails have not been sanded, throw the truck wheels in gear and throw the sand under the shoes of the top carriage, and then sand the rails behind it.

With an average detachment the gun can readily be fired as often as twelve times in an hour, allowing time for deliberate pointing. It has been fired at a sand butt as often as ten times in thirty minutes. In all carriages for heavy guns great care will be taken to keep the bright iron and movable parts, as journals, etc., free from rus

and well oiled. This is especially the case with carriages having air-cylinders. the threads of cylinder-stoppers and pistons of which should be frequently and thoroughly cared for.

MECHANICAL MANŒUVRES.

PART II.

General Directions.

82. The *Mechanical Manœuvres* are the simplest applications of the mechanical powers for mounting, dismounting, moving, and transporting heavy artillery.

83. The implements generally used for the execution of the manœuvres of siege-pieces are:

Handspikes	*Half-blocks*	*Skids*
Long-rollers	*Quarter-blocks*	*Shifting-planks*
Short-rollers	*Gun-chocks*	*Trace-rope*
Half-rollers	*Wheel do.*	*Hammer-wrench.*
Blocks	*Roller do.*	

84. The detachment for mechanical manœuvres consists of a non-commissioned officer and eleven men. It is formed by adding four men—numbered 7, 8, 9, and 10—to the ordinary detachment for serving a siege-piece.

The non-commissioned officer is designated *Chief of section.*

The gunner is always uncovered.

The men are marched to and from their posts, and their posts are changed, as in Nos. 4, 6, 9, and 10. They are posted two yards from the axis of the piece; Nos. 1 and 2 opposite the muzzle; the other numbers and the gunner, dressing on Nos. 1 and 2 respectively, at interva

of one yard, except between Nos. 3 and 5, where there is an interval of two yards.

The chief of section, who is the chief of detachment, is posted two yards in rear of the breech or trail or on the left of the pole, two yards from and opposite its end, according as the piece is dismounted, unlimbered, or limbered. During the execution of the manœuvres he will go wherever his presence may be necessary; but will habitually place himself opposite the gunner, in the interval between Nos. 3 and 5.

85. The men having been marched to their posts, the instructor goes with them for the implements, if they are not already in position, and explains their names, dimensions, uses, and who are to have charge of them. He then commands:

PREPARE TO MANŒUVRE.

The men take the implements, repair to their posts, and place them upon the ground in their rear; the handspikes behind Nos. 1, 2, 3, 4, 5, and 6, perpendicularly to the axis of the piece, their small ends on a line with the right toe; the skids parallel to the piece, their middle behind Nos. 3 and 4; the blocks, half-blocks, quarter-blocks, and chocks equally divided, behind and perpendicular to the skids; the long-rollers and half-rollers near and parallel to the blocks, behind No. 4; and the short-rollers shifting-plank, trace-rope, and hammer-wrench in rear of the gunner.

86. Whenever, in the course of a manœuvre, an implement is not in immediate use, it is returned to its designated place.

87. The instructor gives the commands, and has a general supervision of the manœuvres. He sees that each

man performs the duties assigned him; that everything is in a proper state of readiness before giving the command of execution; and that particular care is taken to avoid all shocks and sudden movements.

88. The chief of detachment attends directly to the execution of the movements, and particularly assists and directs the gunner in all his duties.

89. The gunner places the shifting-plank, attaches and takes off the trace-rope; removes and replaces the elevating-screw; places and removes, and chocks and unchocks, the short-rollers; superintends the righting of the piece, directs the pole of the limber, &c.

Nos. 1, 2, 3, 4, 5, and 6 have charge of the handspikes.

Nos. 1 and 2 rig and work the windlass, raise and lower the chase, &c.

Nos. 3 and 4 chock and unchock the wheels, the gun and the long-rollers; take off and replace the cap-squares; place and remove the skids, blocks, half-blocks, quarter-blocks, long-rollers, and half-rollers; assist Nos. 1 and 2 in lowering and raising the chase, &c.

Nos. 5 and 6 embar on the cheeks, and under the manœuvring bolts; steady and right the piece; assist Nos. 3 and 4 in placing the skids and half-blocks; haul on the rope, &c.

Nos. 7, 8, 9, and 10 assist the others. Nos. 7 and 8 generally assist Nos. 1, 2, or 3 and 4; Nos. 9 and 10 assist Nos. 3 and 4, or 5 and 6: They help to place the implements in preparing to manœuvre; haul upon the rope; and apply themselves by hand to move the carriage.

90. When men on the opposite side of the piece apply themselves to a handspike, the handspike used is that of one of the even numbers: the man to whom it belongs is at the small end, the corresponding odd number at the butt end. Those who assist place themselves inside.

91. When two or more men work at the same end of a handspike, the man to whom it belongs is at the small end.

92. When several handspikes are to be crossed at the muzzle in order to raise or lower it, they are applied in the order of the numbers of the men to whom they belong, those of the highest numbers near the trunnions.

93. The handspikes used in mechanical manœuvres are bevelled on one side, as these will enter into places or under bodies where square handspikes could not be used.

94. When a handspike rests on a fulcrum, and the weight on one end is to be raised by bearing down on the other, the weight should never rest on the bevelled side, as the handspike would not then give a good hold, and would be liable to split. In this case the bevelled side should be down. But if used for lifting, as when two handspikes are crossed under the breech or chase of a gun, to heave it upwards, their ends resting on the ground or platform, the bevelled side should be up.

95. At the completion of each movement of a manœuvre, the men retain the places they are in at its conclusion, ready to proceed to the next movement; resuming their posts only at the command To YOUR POSTS, which is given at the end of each manœuvre.

96. The *front*, when a piece is unlimbered or dismounted is the direction in which its muzzle points; when limbered it is the direction in which the pole points. In the execution of the following manœuvres, when a piece is put in motion on rollers, the terms *back* and *forward* are applied to the direction of the breech and muzzle.

97. A body moving upon a roller gains twice the distance passed over by the roller.

98. The ground should be level and firm, and the implements in good order.

99. Dimensions and weights of implements used in the mechanical manœuvres of siege-pieces.

Implements.	Length.	Width.	Thickness.	Weight.	Remarks.
	in.	in.	in.	lbs. oz.	
Handspike......	84	......	....	12 0	
Long roller.....	42	6	round.	25 0	Grooved ¼-in. deep in the middle.
Short do......	12	7	round.	12 0	
Half do......	46	6	6	31 0	Top rounded 3 inches.
Block..........	20	8	8	26 0	
Half block......	20	8	4	13 0	
Quarter block ..	20	8	2	6 8	Pieces of 2-inch plank or broken handspikes will answer.
Gun chock......	3.6	2.75	2	0 6	Wedge-shape.
Wheel chock....	7	6	3	2 4	Section a triangle. Top rounded ¼ of an inch.
Roller chock....	7	5	2	1 0	
Skid.	72	8	8	97 0	
Shifting plank...	67	12	2.25	48 0	Ends beveled on opposite sides.
Trace rope	360	2.25	round.	7 8	
Hammer-wrench.	......	......	......	2 4	Sometimes called monkey-wrench.

PART. III.

MECHANICAL MANŒUVRES WITH HEAVY GUNS ON TRAVELLING CARRIAGES.

100. The implements required in the manœuvres herein described are only those habitually accompanying each gun and mortar wagon, viz:

WITH THE GUN, 6 (or 4) handspikes, those of Nos. 5, and 6, being the long handspike, (84 inches); 1 short roller; 2 trace ropes, 1 sling chain, (used as a lock-chain); 6 wheel chocks; 4 roller chocks; 1 small screw-jack; 1 monkey-wrench; 2 trunnion-loops.

WITH THE MORTAR WAGON, 6 handspikes; 2 long rollers; 1 trace-rope; 4 wheel-chocks; 6 roller-chocks; 1 1 wrench; 1 shifting-plank.

The manœuvres are arranged on the supposition that no other implements are available. When two or more guns are together, or planks or skids available, as would generally be the case in the field, the manœuvres may be often simplified, as will be indicated.

In the mechanical manœuvres herein prescribed, the general directions laid down in Part II., will be complied with so far as applicable. This is essential for the prevention of confusion and accidents, since directions to particular numbers are in most of these methods omitted.

ORDINARY MANŒUVRES.

101. 1. To limber or to unlimber.

2. To move the carriage when limbered, with and without its piece, by hand to the front or rear.

3. To place the short roller under the chase and to remove it.

4. To place the short roller under the body of the gun and to remove it.

5. To shift the gun from its travelling bed to its firing bed.

6. To shift the gun from its firing bed to its travelling bed.

7. To cross-lift the carriage.

All the other manœuvres are exceptional, and are rarely required in actual service with the guns now mounted on travelling carriages. They are, therefore, prescribed for exercises only to such an extent as may be necessary to enable officers and men to become familiar with the operations.

1. *To Limber.*

102. When these guns are used for field service they may be limbered to the rear, front, right and left.

No. 2 inserts his handspike in the bore and is assisted to bear down by No. 1; No. 6 crosses his handspike under the stock as near the trail as practicable, and is assisted by Nos. 3, 4, 5, 7, and 8. If the limber is not horsed, it is brought up by the chief of piece, gunner and Nos. 9 and 10. The trail is raised at the command HEAVE, until the pintle can be caught under it, and the pole used as a lever to sustain the trail until the handspike can be shifted in

rear of the lunette. The gunner gives the necessary instructions to cause the pintle to enter the lunette, and, when the pintle is in, hooks the lashing chain.

To unlimber, the numbers apply themselves as above.

2. *Forward or Backward March.*

103. The piece being limbered, Nos. 1 and 2 embar obliquely under the rear of the wheels of the carriage; Nos. 5 and 6 in like manner under the limber wheels; Nos. 3 and 4 through the spokes and under the cheeks; Nos. 7 and 8 apply themselves to the limber wheels by hand; Nos. 9 and 10 the splinter-bar; and the gunner at the end of the pole; all facing to the front. The gunner commands HEAVE, and repeats it as often as may be necessary.

In moving to the rear Nos. 1 and 2 embar through the spokes and under the cheeks; Nos. 3 and 4 under the front of the wheels of the carriage. Nos. 5 and 6 under the front of the limber wheels; Nos. 7, 8, 9, 10, and the gunner apply themselves as in moving to the front; all facing to the rear.

The carriage being limbered, but without its piece, the numbers apply themselves as follows at the command FORWARD: Nos. 1 and 2 at the head of the cheeks; Nos. 3, 4, 5, and 6, by hand at the wheels of the carriage. Nos. 7 and 8 at the wheels of the limber; Nos. 9, 10 and the gunner, as with the piece mounted. At the command MARCH the carriage is moved forward.

To move to the rear, Nos. 1, 2, 3, and 4 apply themselves by hand to the wheels of the carriage; Nos. 5 and 6 to the ends of the cheeks; Nos. 7, 8, 9, 10, and the gunner, as with the piece mounted. At the command MARCH, the carriage is moved to the REAR.

In the above movements at the command HALT, all resume their posts.

3. *Place the Short Roller under the Chase.*

The piece being limbered.

104. At this command the wheels are chocked by Nos. 3 and 4; the handspike of No. 2 is placed in the bore; that of No. 6 is crossed under the handspike of No. 2, or under the chase as may be most convenient; No. 1 assists No. 2, Nos. 3, 4, 5, 7 and 8, assist No. 6. The gunner stands between the head of the cheeks with the short roller, and when all is in readiness gives the command HEAVE. The chase being raised high enough the short roller is rolled back on the stock until its axis is six or eight inches in front of the axis of the trunnions and chocked in front, when the piece is allowed to rest on it. (The roller is placed under the chase only when the piece is in its travelling bed, and for the purpose of shifting it to the firing bed.)

Remove the short-roller. Executed as above, except that when the chase is raised the short roller is stopped on the head of the stock by the gunner, to enable the men at the handspike to take a new hold. The chase being raised again, the roller is withdrawn and the piece lowered into its bed.

Either of these operations can be performed, though more time is required, by successive purchases with the handspikes over the heads of the cheeks and under the chase.

4. *Place the Short Roller under the Body of the Piece.*

The piece being limbered.

105. Nos. 3 and 4 chock the wheels and remove the cap-squares; No. 2 inserts his handspike in the bore and is assisted by No. 1 to bear down; Nos. 5 and 6 embar over the cheeks, and under the gun in rear of the trunnions, raising the breech at the command of the gunner, until he can place the short roller under the body of the piece, as near to the trunnions as can be effected readily. The gunner chocks the roller toward the muzzle when the piece is limbered, and in rear when unlimbered, and removes the elevating screw.

The roller is removed in the same manner.

5. *To shift the Piece from its travelling bed to its firing bed.*

The piece being limbered.

106. Place the short roller under the chase. The instructor then commands, SHIFT THE PIECE; Nos. 3 and 4 remove the cap-squares; No. 2 inserts his handspike in the bore and is assisted by No. 1; No. 6 crosses his handspike over that of No. 2 and is assisted by Nos. 3, 4, and 5. The gunner attaches the trace rope at its middle by a double hitch to the knob of the cascable, and passes the ends over the limber to Nos. 7, 8, 9, and 10, who take a turn with each part around the manœuvring bolts. At the command HEAVE, the muzzle is borne down and the piece allowed to run slowly on the roller, until the trunnions are over their firing beds, when they are borne down into place, and the short roller removed from the rear. Nos. 3 and 4 replace the cap-squares.

Before executing this or any similar manœuvre, the man-

œuvring bolts should be set tight to the stocks with the wrench, if necessary, to prevent accident from turning. The precaution should be taken also of putting a chock near the head of the stock to stop the roller, should the men at the trace rope fail to control the piece after the trunnions have been lifted over the chin-bolts. *The gunner must observe that the lashing-chain is hooked.*

6. *To Shift the Piece from its Firing Bed to its Travelling Bed.*

The piece being limbered.

107. Place the short roller under the body of the piece. At the command SHIFT THE PIECE, the handspike of No. 4 is crossed under that of No. 2, and manned by Nos. 1, 2, 3 and 4. The gunner attaches the trace rope at its middle to the knob of the cascable by a double hitch, and passes its ends over the limber to Nos. 5, 6, 7, 8, 9 and 10. At the command HEAVE and HAUL, by the gunner, the piece is pushed and hauled until the trunnions are over their travelling beds, when the breech is allowed to rest on the bolster. The roller is removed from the front by raising the muzzle as described in manœuvre (3), and Nos. 3 and 4 replace the cap-squares.

7. *To Cross-lift the Carriage.*

108. The piece is mounted, the carriage unlimbered.

To cross-lift to the right, Nos. 2 and 4 embar under and perpendicularly to the left wheel from the outside; Nos. 1 and 3 under the right wheel from the inside, No. 1 passing to the left of the piece, and No. 3 stepping over

the stock for this purpose. The carriage is lifted short distances at the command HEAVE from the gunner. To cross-lift to *the left* is executed in the same manner but by inverse means.

In any of the preceding manœuvres with the 8-in. howitzer where the handspike of No. 2 is inserted in the bore, it should be chocked about 18 inches in the bore, and again at the muzzle.

When the howitzer is transported on its travelling bed, a temporary bolster should be constructed to support the breech. The short roller resting on a piece of plank, two or three inches thick and supporting the knob of the cascable, will answer for this purpose.

NOTE.—The requirements of paragraph 95, p. 274, will be observed in all the foregoing manœuvres.

OTHER MANŒUVRES WHICH MAY BE REQUIRED IN SERVICE.

1. *To Mount the 4½-inch Gun on its Carriage.*

109. The piece is lying on the ground, vent uppermost. The carriage is unlimbered, the elevating-screw and cap-squares removed, the trail about two yards from the muzzle, and the stock squarely in the prolongation of the gun. Lay the sling chain under the cascable against the breech. Raise the muzzle by lifting with and cross-lifting under a handspike in the bore, and support it in this position by cross-lifting under the chase, or otherwise, and back up the carriage until the muzzle will catch

on the short-roller placed on the end of the stock. By shifting the roller frequently to avoid the nuts and bolster, the carriage may be worked under the piece, the numbers applying themselves nearly as in FROM BATTERY, until the trunnions are about over the manœuvring bolts. Shift the roller in front of the elevating screw-box, and sling the piece under the limber by the knob of the cascable as high as practicable. If it be well slung the carriage can be moved back until the trunnions strike the travelling trunnion-bolts. Chock the roller in rear and let the breech rest squarely on the bolster. Secure the piece in this position by laying the middle of a trace-rope over it just in rear of the trunnions, carrying the ends to the front under them and tying to the axle-tree. Sling the stock under the limber as high as practicable, by the manœuvring bolts, (this can best be accomplished by doubling the sling chain, passing the middle of it under the stock from left to right, and placing the bight over the right manœuvring bolt. Back the limber so that the end of the fork will have free play on the left of the stock when the pole is raised. Attach the trace rope to the end of the pole, raise the pole to a vertical position, the pintle should then be over and slightly to the rear of the left manœuvring bolt. Bring up both ends of the sling chain *behind* the left manœuvring bolt, pass the hook end round the pintle, taking in all the slack, fasten in a convenient length, man the trace rope, and haul down); shift the short roller just in front of the trunnions, remove the trace rope from the piece; attach it at its middle to the knob of the cascable; bear down and raise on a handspike in the bore, hauling on the trace rope at the same time, until the trunnions clear the chin-bolts, when the muzzle will at once be borne down, causing the trunnions to drop

into their firing-beds. As the muzzle approaches the ground the handspike must be shoved into the bore. Remove the short roller by the rear.

In slinging the piece attach one end of the trace rope to the end of the pole, and chock the limber wheels front and rear and the carriage wheels in front. The ease with which the manœuvre is performed depends upon the skill with which the slinging is effected. When the stock is slung it should be nearly horizontal, and if it is not effected when the first lift is taken it is better to support the stock and shorten the sling chain for a new lift. No more than three men are required at any time to hold the pole down, and they leave in succession as the weight is removed from the pole and repair to the rope.

2. *To dismount the Piece from the Carriage.*

110. The piece is limbered. Place the short roller under the body of the gun, chocking it on the side of the limber; chock the wheels; attach the trace rope as before to the knob of the cascable, and take two turns with each end round the manœuvring bolts, hauling taut, and placing two men on each end to slack off when directed. Lift at the muzzle keeping the rope taut, ease the trunnions over the eye bolts and rest them on the cheeks. Slack off carefully on the trace rope until the muzzle strikes the ground; take off the rope, unchock the wheels and run the carriage forward until the piece drops to the ground.

In performing this manœuvre with a single roller the breech is sometimes jammed between the cheeks, or the head of the stock bruised by the knob of the cascable. Both of these difficulties are obviated entirely by using

two short rollers, the second one being rolled down the stock and chocked against the first before runningthe carriage out.

If the piece is dismounted in this manner on hard stony soil, some material, as hay, brush, etc., should be placed to receive it in its fall.

NOTE.--In the above or other manœuvres prescribing its use, should no limber be immediately available, the stock may be temporarily supported in a horizontal position by means most convenient.

3. *To shift the 4½-inch Gun from one carriage to another.*

111. The piece is unlimbered; the spare carriage limbered (cap-squares and elevating screw removed) is placed accurately in the same direction, distant two or three yards from the end of the trail.

Place the short roller under the body of the piece, raise the chase until a wheel chock (base up), or the butt end of a handspike can be placed under the trunnions; attach the trace rope at its middle to the knob of the cascable; back up the s are carriage wheel to wheel, chock in this position, and run the ends of the trace rope across the spare carriage. Lay one end of a shifting plank on the head of the stock of the spare carriage, the other end, beveled side down, on the stock under the gun; bear down on the muzz'e until the short roller can be placed about eight inches in rear of the trunnions, and have at the same time a bearing of three or four inches on the shifting plank. With four men at the muzzle and six at the trace ope, HEAVE and HAUL until the trunnions are over the beds on the spare carriage. Embar over the cheeks of the now free carriage and under the chase and

draw out the shifting plank and short roller; replace the short roller on the head of the stock of the free carriage and let the muzzle rest on it; and run the carriage forward by hand.

4. *To Mount the Gun upon the Mortar-Wagon.*

112. The gun is lying on the ground, the mortar wagon unlimbered, its stakes and bolsters removed, is in the prolongation of the piece, its trail on the ground about two yards from the breech.

Raise the muzzle and place one of the long rollers under the trunnions; tip the muzzle down and back the trail of the mortar wagon until the breech catches on the other long roller placed on the end of the stock and chock the wheels. Attach the middle of the trace rope to the windlass; pass the ends over and under the trunnions, and tie them by a square (flat) knot on the top of the piece. (If the windlass be provided with a pawl and ratchet attachment, take the trace rope at its middle, pass it over the piece in front of the trunnions, bring the ends under the trunnions to the windlass, taking a turn with each end around the windlass, placing two cannoneers to take up the slack.) Draw the gun up the stock by the windlass, feeding the second roller under the breech when the first roller is nearly under the trunnions. The chase may be allowed to run on one of the rollers until the gun has the same inclination as the stock, or the wheels may be left unchocked so that the strain on the trace-rope will work the stock under the gun; but no difficulty will be found with the guns now mounted on travelling carriages.

Draw the piece back on the wagon until the trun-

nions are about eighteen inches in front of the axle-tree, replace the bolster, and chock both the roller and wheels front and rear. Six men will now be able to raise the trail, (which may be temporarily supported on one of the long rollers placed on end), and the rest of the detachment bring up the limber. The wagon being limbered, the piece is stowed by hauling it forward until the breech is against the hurter, and then removing the roller to the front.

With heavier guns, this manœuvre is rendered easier by raising the breech until the inclination of the piece conforms more nearly to that of the stock, and supporting it temporarily in this position by pieces of timber. The end of the stock may also be raised on skids. This becomes more essential as the piece increases in weight The limber of the wagon may often be used to sling the piece until the breech rests on the roller placed on the stock, and subsequently to sling the muzzle clear of the ground to prevent its dragging.

5. *To dismount the Gun from the Mortar-Wagon.*

113. Cross-lift over the stock and under the chase, and raise the muzzle by successive purchases until a long roller can be placed under the gun a short distance in front of the trunnions. Tip the muzzle down, insert the other long roller under the piece about eighteen inches in rear of the trunnions, and remove the bolster. Attach the end of the trace-rope over the trunnions as in mounting the piece, rig the windlass and haul the gun back until the trunnions are about eighteen inches in front of the axle-tree, and chock both rollers. Chock also the windlass roller, (when there is no pawl and ratchet attach-

ment), by resting one of the roller handspikes against the knob of the cascable. Six men at a handspike crossed under the stock will now be able to raise it until the carriage can be unlimbered, and lower the trail to the ground. There is no danger of the piece slipping to the rear during this operation, if the weight is kept the proper distance in front of the axle. The gun is then lowered by means of the windlass, receiving the muzzle on the shifting plank and pinching it forward with the handspike, or letting it run on a roller.

6. *To shift the Gun from its carriage to the Mortar-wagon.*

114. The piece is limbered. Place the mortar-wagon in the rear and prolongation of the carriage but faced in the opposite direction, the windlass two or three yards from the head of the stock. Place the short roller under the body of the piece, attach the trace-rope to the knob of the cascable ; lift at the muzzle, and push and haul the piece back until the trunnions are just behind the chin bolts. Remove the short roller ; back up the mortar wagon wheel to wheel, and chock ; lay the shifting-plank from the head of the stock to the mortar wagon, and place the short roller on it and under the chase, working it back as far toward the trunnions as practicable by successive purchases over the cheeks and under the chase. Remove the bolster (which is useful as a fulcrum) ; take a turn around each manœuvring bolt with the trace-rope ; bear down on the muzzle and permit the piece to run forward on the wagon, receiving the chase on one of the long rollers.

To shift the Gun from the mortar-wagon to its Carriage, the latter being limbered, is an operation so similar to the above as to need no description. The trun-

nions being over their beds, the shifting plank and short roller are extricated by cross lifts under the chase, which rests on a long roller, so placed that when the mortar-wagon is run to the front the muzzle will clear the wagon when it drops from the roller and permit the trunnions to fall into their beds. Meanwhile the piece is held fast by taking one or two turns of the trace-rope round the manœuvring bolts.

The gun may be shifted to the mortar wagon (the piece being limbered) without a shifting plank, by the use of a second short roller to receive the body of the gun on the mortar wagon. The preliminaries are the same as above, the trunnions being held on the cheeks. The short roller is then placed well up just behind the trunnions, the trace rope taut and around the manœuvring bolts ; the muzzle is raised, the wagon backed wheel to wheel and the muzzle rested on a long roller. The second short roller, placed on the rear cross-bar plate, receives the body of the gun as the first roller runs off the head of the stock.

The same implements suffice to shift the gun from the wagon to its carriage.

7. *To dismount the 8-inch Howitzer from its Carriage.*

115. The piece is limbered or unlimbered. Remove the quoin : attach the trace rope to one of the manœuvring bolts ; chock the wheels front and rear ; place the shifting-plank or the handspikes to receive the muzzle, the end of the plank or butts of the handspikes under the axle ; raise the trail (if limbered, run out the limber), the gunner following up and supporting the stock with the long handspike, butt end on the ground, until the muzzle rests squarely on

the shifting-plank. Nos. 7, 8, 9, and 10, quit the stock in succession as the weight passes from it, and man the rope. Nos. 3 and 4 now remove the cap-squares. The gunner cautioning 7, 8, 9, and 10, to keep a slight strain on the trace-rope, directs 3 and 4 to move the rear wheel-chocks two or three inches back ; Nos. 5 and 6 at the wheels then move the carriage back, 1 and 2 steadying the piece if necessary, and 3 and 4 following up the wheels with the front chocks. This movement is repeated under the direction of the gunner, until the carriage is backed sufficiently far for the cheeks to clear the trunnions, when the trail is lowered. The gunner regulates the position of the handspike supporting the trail at each movement of the wheels, so as to keep the preponderance of the trail to the rear without lowering it so much as to cause the eyebolts to interfere with the piece. The trail is then lowered.

8. *To mount the 8-inch Howitzer on its Carriage.*

116. The piece is standing on its muzzle on the ground, the carriage unlimbered, as close to the piece as practicable, and have the heads of the cheeks clear the trunnions when the trail is raised ; the wheels chocked front and rear, the manœuvring bolts screwed tight to the stock. Attach the trace-rope by its middle to the knob of the cascable, and take a turn with each end around the manœuvring bolts. Raise the trail nearly vertical, keeping four men at the trace rope to take up the slack of the rope and to prevent the trail from falling to the front; the gunner follows up the movement with a long handspike placed against the stock, the butt end on the ground to support it in rear. The trail being raised, move the front chocks forward a few inches at a time and work the

wheels carefully forward, raising the trail again after each movement. if necessary, until the trunnions rest against the cheeks near the eye-bolts and if possible behind them. Put the sling-chain around the piece from behind and bring the ends up over the trunnions and through the beds; or if the links are large enough, catch two of them over the chin-bolts; the chain being hauled taut. Haul down on the trace-rope. If the piece stands on soft ground, assist at the start by embarring under the muzzle and over a chock. As the weight comes on the stock, man it by the men taken in succession from the trace rope, and lower the trail to the ground. If the piece has been well slung the trunnions will rest on the cheeks. To get them into their beds, put the short roller under the breech; take a turn with each end of the trace-rope around the axle-tree; raise the muzzle and slacken carefully on the rope until the trunnions are in place.

This manœuvre, like the preceding one, is rendered less troublesome by the increased facilities afforded by the presence of another detachment, and planks or blocks on which to stand the muzzle. Two trace-ropes being available, use them as guys to prevent the trail from falling, and thus remove the only source of danger.

To stand the Howitzer on its muzzle. The piece is lying on the ground. Raise the muzzle, pass a shifting plank (or two handspikes) under the trunnions, perpendicular to the axis of the piece, place a short roller on the plank, under the trunnions and chock it front and rear. Bear down the muzzle, at the same time cross-lifting under the cascable, until the muzzle is on the ground, and sustain the piece in this position by cross-lifting under the breech. Fasten firmly the middle of a trace-rope to the middle of a long handspike by two half-hitches; place the handspike

under the cascable; bring up the ends of the rope, one on each side of the cascable, cross them above it on the breech, and haul taut. Nos. 1, 2, 3, 4, 5, and 6 man the handspikes; Nos. 7, 8, 9, 10, gunner, and chief of piece man the rope. The gunner then commands HEAVE, and all lift and haul until the piece stands on the muzzle.

Two handspikes may be placed on the ground about 6 inches apart, parallel to the prolongation of the axis of the piece, but with bevelled sides up, against the face of the piece, and the howitzer placed on its muzzle on the handspikes, as described above, except that the howitzer after being raised must be worked forward until it is firm on the handspikes. A shifting-plank may be used instead of the handspikes. If the ground is soft more handspikes may be used.

To mount the Howitzer when placed as above. The piece is standing on its muzzle on a shifting-plank or handspikes, the carriage unlimbered and as close to it as practicable, and have the cheeks clear the trunnions when the trail is raised. Chock the wheels front and rear; attach the rope to one of the manœuvring bolts; raise the trail until it is nearly vertical, 7, 8, 9, and 10 passing to the rope after the trail is supported by the handspike. The trail is raised slowly, 7, 8, 9, and 10 being careful that it does not pass the perpendicular, and the gunner that the supporting handspike is properly placed. Nos. 3 and 4, at the direction of the gunner, move the front chocks two or three inches to the front, and Nos. 1, 2, 5, and 6, at the wheels, move forward the carriage, 3 and 4 following up the wheels with the rear chocks. The trail is again raised to nearly the perpendicular, and the handspike adjusted by the gunner. These movements are repeated until the trunnions rest in their beds, when the

cap-squares are secured by 3 and 4, and the trail lowered to the ground. Nos. 1 and 2 assist by lifting at the muzzle.

9. *To dismount a Carriage and its limber.*

117. The carriage being without its piece, and unlimbered, may be dismounted by removing the wheels in succession, and lowering the carriage to the ground or upon blocks. A long handspike is crossed under the axle-tree, as near to the wheel as possible, to which 6 men apply themselves. Two men apply themselves to the wheel and the remainder of the detachment to the most convenient parts of the carriage. The wheel being removed, the axle-tree is lowered to the ground, or on a block, and the other wheel removed in like manner.

The carriage may be mounted in a similar manner. It may sometimes be advantageous to raise the carriage to the necessary height by successive purchases with handspikes, and support it on props. The limber may also be used to lift the carriage, but it will be generally found more expeditious to mount it as above described.

THE LIMBER is readily dismounted, and mounted, by passing the long handspike between the sweep-bar and axle-tree, the butt ends resting upon the splinter-bar; 6 men lift on the handspikes and two at each wheel.

118. THE MORTAR WAGON may be dismounted in like manner, the handspikes being passed under the windlass and over the axle-tree.

119. *To change or grease a Wheel*, the lifting jack is applied under the axle-tree near the wheel to be removed; or the wheel may be removed by a single lift on the long handspike crossed under the axle-tree; but with the heavier

carriages the axle must be temporarily supported by a prop.

By using the trail as a lever, a wheel may be changed when the piece is unlimbered, as follows: Raise the trail as in limbering, and place a prop, about thirty inches in length, under the cheek close in rear of the axle-tree on the side on which the wheel is to be changed. Bear down on the trail and the wheel will be clear the ground.

MECHANICAL MANŒUVRES WITH THE 24-POUNDER FLANK CASEMATE HOWITZER.

In the mechanical manœuvres herein prescribed the general directions laid down in Part II. will be complied with so far as applicable. This is essential for the prevention of confusion and accidents, since directions to particular numbers are in most of these methods omitted.

120. The Implements necessary are:

One half-roller	*Four blocks*
Two half-blocks	*Four gun-chocks*
Two skids	*One hammer-wrench.*

To dismount the howitzer carriage from its chassis, the piece being mounted and "from battery."

121. The instructor commands:

DISMOUNT THE CARRIAGE.

Nos. 1, 2, and the gunner remove the pintle and run the carriage into battery. The gunner, assisted by Nos.

3 and 4, take off the three nuts that hold the fork; a handspike, manned by Nos. 1, 2, 5, 6, is passed under the chassis immediately in rear of the fork, and at the command HEAVE from the gunner, the chassis is raised, the fork removed, and the trail carefully lowered to the ground. Nos. 3, 4, 5, and 6 then lay the skids in rear and in prolongation of the chassis, their outer edges in line with those of the chassis. Nos. 1, 2, and the gunner, then run back the carriage (applying themselves as in "from battery"), until the rear end of the cheeks touch the counter-hurters.

The gunner bears down on the roller handspike to raise the trail as much as possible, and assisted by Nos. 3 and 4, who place the bevelled ends of their handspikes under the outer edges of the trail, lifts it over the counter-hurters on to the skids.

When the front rollers touch the counter-hurters, No. 2 puts his handspike into the bore and chocks it. Nos 1 and 2, assisted by No. 5, raise the muzzle. Nos. 3 and 4 lift at the manœuvring rings and run back the carriage until the front rollers rest on the skids. No. 2 lays down his handspike, and Nos. 1, 2, 3, 4, and the gunner (the latter embarring in the left mortice, and pressing the roller under the rear transom, and Nos. 1, 2, 3, and 4 laying hold of the manœuvring rings and handles), run the carriage back on the skids until the muzzle is over their front ends.

REMARKS.—The counter-hurters may be removed at the same time with the fork, and the difficulty of raising the carriage over them obviated; or gun chocks can be placed against the counter-hurters.

To dismount the Howitzer.

122. The instructor commands:

DISMOUNT THE HOWITZER.

Nos. 3 and 4 remove the cap-squares and lay a block and a half-block across the skids touching the head of the cheeks. No. 2 inserts his handspike in the bore, chocks it, and assisted by Nos. 1 and 5 raises the muzzle high enough for No. 4 to place a half-roller on top of the blocks. The chase is rested on this half-roller and chocked on each side. No. 6 now crosses his handspike under the knob of the cascable, No. 5 taking hold of the other end. Nos. 1 and 2 bear down on the handspike in the bore. Nos. 5 and 6 lift on that at the cascable. The gunner and Nos. 3 and 4 back the carriage until the front rollers rest on the rear ends of the skids and the trail is on the ground. Nos. 3 and 4 then place a block and a half-block across the skids under the breech.

Nos. 5 and 6 bearing down on their handspikes at the cascable and Nos. 1 and 2 lifting on theirs, raise the muzzle, and Nos. 3 and 4 remove the half-block from under the half-roller. The muzzle is in like manner lowered and the half-block removed by Nos. 3 and 4 from under the breech. The muzzle is again raised and Nos. 3 and 4 remove the block from under the half-roller and place the half-roller under the trunnions. The muzzle is borne down and Nos. 3 and 4 remove the block from under the breech and replace it by a half-block. The piece may now be slewed in any direction, rolled upon blocks, or placed in any required position.

To mount the Howitzer when on the skids and resting on the half-block and half-roller.

123. The instructor commands:

MOUNT THE HOWITZER.

No. 2 inserts his handspike in the bore, and assisted by No. 1, prepares to bear down on the muzzle. No. 6 crosses his handspike under the knob of the cascable and, assisted by No. 5, prepares to lift at the breech. At the command HEAVE, they lower the muzzle, and Nos. 3 and 4 replace the half-block under the breech by a block. At the command EASE AWAY, the breech is lowered on the block and chocked. The muzzle is next raised by the same Nos. at the handspikes, and Nos. 3 and 4 insert a half-block under the half-roller, so that the front scaffold thus formed is 3 or 4 inches in front of the junction of the chase and reinforce. The muzzle is now lowered and a half-block placed by Nos. 3 and 4 on top of the block under the breech.

The muzzle is next raised and a block placed by Nos. 3 and 4 under the half-block, thus forming under the chase a scaffold consisting of a half-roller, a half-block and a block. Nos. 3 and 4 now remove the cap squares, and the gunner, assisted by these Nos., places the front of the carriage on the skids as near the gun as convenient, the trail resting on the ground. Nos. 1 and 2 bear down on the handspike in the bore, and Nos. 5 and 6 lift at that under the knob of the cascable. Nos. 3 and 4 remove the rear scaffold and, with the gunner, run up the carriage until the trunnion-beds are under the trunnions. Nos. 1 and 2 raise on their handspikes. Nos. 3 and 4

remove the front scaffold, and the trunnions are lowered into their beds. Nos. 2 and 6 lay down their handspikes, and Nos. 3 and 4 put on the cap-squares. All then run the carriage forward until the front rollers touch the counter-hurters

To mount the Carriage upon its Chassis.

124. The instructor commands :

MOUNT THE CARRIAGE UPON THE CHASSIS.

No. 2 inserts his handspike in the bore and, assisted by Nos. 1 and 5, (the gunner bearing down on the roller-handspike), raises the front of the carriage. Nos. 3, 4 and 6 at the same time push the carriage forward until the front rollers pass over the counter-hurters, and the guide of the front transom enters into the guide-space. No. 2 now lays down his handspike. The gunner again bears down on the roller-handspike, and all push the carriage forward ; No. 6 with a handspike at the trail assisting to pass it over the counter-hurters, and guiding the flange of the roller into the guide space.

No. 6 then crosses his handspike under the knob of the cascable and, assisted by No. 5, presses against the base of the breech. Nos. 3 and 4 seize the trail handles, and Nos. 1 and 2 the manœuvring rings. The gunner bears down on the roller-handspike. All act together and run the piece up the chassis into battery.

Nos. 1, 2, 5 and 6 now apply themselves to a handspike crossed under the rear end of the chassis, which they raise and hold up while the gunner, assisted by Nos. 3 and

4, replace the fork and nuts. The piece is then run from battery, and the gunner, assisted by Nos. 1 and 2, put in the pintle.

NOTE.—In replacing the fork after the howitzer and carriage have been mounted difficulty sometimes results from the unsteadiness of the chassis as held up by Nos. 1, 2, 5, and 6. This can be remedied by supporting the chassis on a platform consisting of a block placed on end on another block laid down flat upon the platform. Sometimes the height of this platform has to be increased by a half-block placed on top of the block which is on end. Should the fork be sprung it may become necessary to secure the brace with its nut before the branches are placed on their bolts.

PART IV.

MECHANICAL MANŒUVRES WITH 10-INCH SIEGE MORTAR.

In the mechanical manœuvres herein prescribed, the general directions laid down in Part II., will be complied with so far as applicable. This is essential for the prevention of confusion and accidents, since directions to particular numbers are in most of these methods omitted.

The Mortar lying on the ground, or on its platform, to stand it on one of its trunnions.

125. Implements required :

One trace-rope.

The rope is passed around one of the trunnions from underneath and over the mortar, and manned by all the cannoneers except the gunner, who passes the handle of the elevating bar through the clevis-lug and steadies the piece as it is pulled over on its trunnion by the trace rope.

The Mortar resting on one of its trunnions, to stand it on its muzzle on the ground, or on its platform.

126. Implements required :

One trace-rope.

The gunner passes the middle of the trace-rope under the mortar in front of the trunnion, carries the two ends back, crosses them over the breech and passes them to the front, one on each side of the upper trunnion. He then puts the handle of the elevating-bar through the clevis-lug to steady the mortar which is hauled on its muzzle by the rest of the detachment at the trace-rope.

The Mortar being on its muzzle, to slue it in either direction.

127. No. 5 and 6 embar against the trunnions in opposite directions to turn the mortar about the axis of the bore, or on the same side of the trunnions to shift its position.

To dismount the Mortar.

128. The bed is on the platform or ground.

Implements required:

One wrench. *One long handspike.* *One trace-rope.*

The instructor commands:

DISMOUNT THE MORTAR.

The gunner, assisted by No. 4, gives the mortar an elevation of twenty-one degrees, throws the bight of the trace rope over the pipe and drawing the ends through the loop passes them to the rear to Nos. 7, 8, 9 and 10, who haul on them with sufficient force, when the bed has been raised, to keep it from falling to the front. No. 6 passes

his hands ike under the rear notches and over the rope, No. 5 seizing the butt end and the cannoneers man the handspike in the following order from right to left: Nos. 5, 3, 1, 2, 4, 6, all facing to the front. The instructor commands HEAVE, the numbers at the handspike raise on it until the muzzle of the mortar rests upon the platform or ground. The cap squares are removed by Nos. 3 and 4, assisted by Nos. 1 and 2, and placed one yard in rear of their posts, the nuts on the cap squares. All the cannoneers, except Nos. 5 and 6 at the handspike, man the rope. The instructor commands LOWER THE BED, HEAVE. The cannoneers haul upon the rope and the four nearest the mortar leave it in succession and apply themselves to the handspikes as the weight comes upon it, to prevent any unnecessary shock. The cap squares are replaced by Nos. 3 and 4. No. 6 removes his handspike, the gunner removes the trace-rope.

To mount the Mortar.

129. The mortar is standing upon its muzzle. The bed sixteen inches from it on the side opposite the vent.

The instructor commands, MOUNT THE MORTAR, HEAVE. The cap squares are removed by Nos. 3 and 4 and placed in rear of their posts. The cannoneers apply themselves to the rope and handspike as described in dismounting. When the weight of the bed is fairly supported by the rope, Nos. 3 and 4 take their own handspikes, embar against the manœuvring bolts and move the bed as may be necessary until the trunnions are in their beds. Assisted by Nos. 1 and 2 they then put on the cap squares. The instructor commands, LOWER THE MORTAR, HEAVE. Nos. 3 and 4 facing to the rear, embar under the cap squares,

and subsequently under the face of the mortar, the other cannoneers apply themselves at the rope and handspike, and the mortar is lowered as is prescribed for lowering the bed.

To mount the Mortar upon the Mortar-Wagon.

[REMARK.]—The wagon here referred to is the old pattern altered to adapt it to the new bed which is about twelve inches longer than the old bed. By lengthening the wagon body, the windlass is thrown twelve inches further from the axis. Hurters are placed on the rear cross-bar plate against which the bed abuts when the mortar is in the most convenient position for limbering up. The bridle bolts on the stock are also counter-sunk.

130. Implements required.

Two long rollers.	*Six wheel chocks.*
Four roller chocks.	*One trace rope.*

The mortar is on its bed, the bed on the platform or on the ground. The trail of the mortar wagon, its stakes and bolster removed, is about two yards from the rear transom and perpendicular thereto.

To run up the wagon and place the rollers.

The mortar bed is raised nearly vertical, as in dismounting the mortar from its bed, Nos. 1, 2, 3, 4, 5, and 6 applying themselves to the handspike of No. 6 ; as soon as the mortar is raised, Nos. 7 and 8 embar under the stock to guide it under the bed midway between and parallel to the cheeks. Nos. 9 and 10 working at the wheels. The stock is run under the bed as far as practi-

cable and the long roller placed on it by the gunner in such a position that when the bed is lowered the point of contact with the roller shall be twenty inches from the toes of the shoes. Nos. 3 and 4 chock the wheels front and rear, and No. 4 stands ready to engage the second roller under the bed. No. 4, assisted by No. 3, shifts the long rollers in mounting and dismounting the mortar.

To rig the Windlass.

The windlass is rigged and manned for the old pattern mortar wagon in the following manner, viz.: Nos. 1 and 2 go to the rear of the wagon and attach the middle of the rope to the windlass, they are assisted by Nos. 7, 8, 9 and 10. The gunner attaches the rope to the rear manœuvring-bolts. Nos. 5 and 6 embar under the front manœuvring-bolts.

Nos. 1, 2, 7 and 8 heave upon the windlass, and Nos. 9 and 10 press against the rope with the handspikes of Nos. 1 and 2 to prevent its turns spreading too much on the roller, Nos. 5 and 6 urge the mortar up until it is ascending the stock; they then place the butt ends of their handspikes upon the stock, bevelled sides down just below the lower roller, and follow up the movement. Nos. 3 and 4, aided by Nos. 5 and 6 with their handspikes, shift the rollers, and chock them whenever necessary. When the rear end of the cheeks have arrived on the body of the wagon, the lower roller, on becoming disengaged, is taken away by No. 4, and the mortar is drawn up on the roller, until the rear ends of the cheeks touch the rear cross plate; Nos. 9 and 10 holding their handspikes under the rear manœuvring bolts in order to ease the bed when it cants to the rear. Nos. 1 and 2 chock the windlass by allowing

the handspike in the upper portion to rest against the mortar. To RIG THE WINDLASS with the pawl and ratchet attachment, the middle of the trace-rope is attached to the rear manœuvring bolts, or to the pipe, and the ends carried to the windlass roller, where two or three turns are taken around and the slack carried to the rear. Nos. 7 and 8 haul in and lower away the slack.

As soon as the mortar is in motion the second long roller is engaged under the shoe by No. 4, twenty inches from the lower roller, measuring from axis to axis. The lower roller will then disengage just as the mortar is balanced on the upper roller. Nos. 5 and 6 steady the piece with their handspikes.

As soon as the lower roller is disengaged it is taken out by Nos. 3 and 4 who again engage it twenty inches above the other roller. The mortar is drawn back on the last roller placed, until the heels of the shoes abut against the hurters on the rear cross-bar plate. The roller is now chocked front and rear by Nos. 3 and 4.

To limber up.

Nos. 7, 8, 9, and 10 bring up the limber. Nos. 1 and 2 remain at the windlass handspikes, and by bearing down prevent the mortar from sliding on the roller. No. 6 crosses his handspike under the stock in front of the lunette, and is assisted to lift by Nos. 3, 4, 5, 7 and 8. Nos. 1 and 2 bear down on the windlass handspikes, diminishing their efforts as the stock is raised. The stock is raised until the gunner and Nos. 9 and 10, by raising the pole of the limber, can engage the pintle under the trail, and use the pole as a lever to hold up the stock until the handspike can be shifted six inches behind the manœuvring staple. Nos. 3

and 4 leave the handspike and lay hold of the limber wheels, and guide the pintle into the lunette. When the handspike is shifted, Nos. 5 and 6 lift at the ends, Nos. 7 and 8 next to the stock facing to the rear.

In raising the stock, in limbering and unlimbering, great care must be taken not to raise it so high as to endanger the overturning of the mortar wagon to the rear.

To stow the mortar.

No. 4 removes the front roller chock and satisfies himself that the rear roller chock is in place. Nos. 5 and 6 embar over the side rails and under the shoe, near the rear notches, to cant the bed to the front. Nos. 1, 2, 7, and 8 ease away gently and permit the bed to move forward on the roller until the front notches are over the front cross bar-plate. If the bed does not move far enough forward on the roller after canting, Nos. 5 and 6 embar over the side rails, and under the front notches, and pinch the bed forward to its place. The roller is then removed from the rear and the bed lowered on to the wagon by repeated purchases, the disengaged roller chocks, and handspikes being placed by the gunner as fulcrums on the rear of the wagon. If the mortar is to travel, the bed is firmly chocked, and the implements are stowed on the wagon and well lashed to their places.

To dismount the mortar from the wagon.

131. The bed is raised by repeated purchases until the long roller can be placed so far under from the rear t at the points of contact shall be two feet from the toes of the s oes.

To rig the windlass.

The windlass is manned and rigged as in mounting the mortar, except that with the old pattern mortar wagon the rope is wound up on the windlass before the ends are made fast to the manœuvring bolts. The mortar is then drawn back against the hurters, Nos. 5 and 6 embarring under the shoes and over the side rails to ease the bed when it cants to the rear. Nos. 3 and 4 chock the roller front and rear.

To unlimber.

The handspike of No. 6 is passed under the stock and manned as in limbering up. The stock is carefully raised, Nos. 1 and 2 assisting by bearing down on the windlass-handspikes, until Nos. 9, 10 and the gunner can clear the pintle from the lunette and remove the limber. The stock is then gently lowered to the ground.

The mortar is then eased down the stock by the windlass. The second long roller is engaged under the front of the bed, as soon as the mortar cants to the front, so that the distance between the rollers, measuring from axis to axis, shall be twenty inches ; the rollers are shifted in this manner by Nos. 3 and 4 until the bed rests on the ground. Nos. 5 and 6 with their handspikes steady the mortar while being eased down the stock. Nos. 3 and 4 unchock the wheels, and the wagon is run back by Nos. 5 and 6 at the stock, and Nos. 7, 8, 9 and 10 at the wheels. The rope is removed by Nos. 1, 2 and the gunner. The long roller is removed as it was placed under the bed.

REMARKS.—With the old pattern mortar wagon it is impracticable to draw the mortar far enough to the rear to limber up in the usual way.

The only safe plan is to raise the stock by successive cross-lifts, and blocking the stock up by scaffolding just behind the manœuvring staple. One of two whole blocks, bearing a third block on end will bring the stock to about the proper height, thirty-six inches. To prevent the mortar bed from slipping on the roller, a handspike should be placed between the windlass roller and rear cross-bar plate, abutting against the corner of one of the cheeks.

If there are no rear manœuvring bolts on the bed, the trace rope may be made fast by timber hitches around the transom and over the corners of the cheeks.

To mount (or dismount) a Sea-coast Mortar.

132. The sea-coast mortars are best mounted and dismounted by gins. The block is hooked into a clevis attached to the clevis-lug. It is necessary to remove the upper step or transom of the bed and level the mortar before hoisting the mortar.

In the absence of a gin, the mortars may be dismounted by hydraulic jacks and blocks. The steps, diagonal braces, and transoms, excepting the pipe, are removed and the muzzle depressed about two degrees, the breech resting on a scaffolding and chocked on each side. The jack is p'aced under the muzzle, and the mortar is raised until its weight is off the trunnion beds. A scaffolding under the muzzle sustains the mortar in this position, until the cheeks are taken apart and the bed removed.

The mortar may be mounted by raising it on blocks at the proper height, the jacks being applied under the trunnions, and then assembling the cheeks under the mortar.

Transporting the Mortar.

133. The 13-inch mortar, without its bed may be transported by using two sling-carts in the following man-

ner: Remove the pole of the rear sling-cart and place heavy skids on the bolsters of the carts, lashing the forks of the rear cart to the skids. Raise the mortar then by means of jacks or blocks and suspend it by chains to the middle of the skids. The sling-carts may be used also without removing the pole, by placing the sling-carts over the mortar with the poles in opposite directions, and placing the skids on the bolsters as above directed. The dismounted mortar may be rolled on skids by means of pinchbars or by parbuckling. The mortar on its bed may be placed upon the new fourwheeled truck for transportation.

To place the 13-*inch Mortar and bed on rollers.*

134. The following implements are necessary;

4 *Rollers.*
4 *Whole blocks.*
4 *Half blocks.*
2 *Quarter blocks.*
4 *Roller chocks.*

Embar over a block and under the rear notches perpendicular to the cheeks, and raise the rear of the mortar bed until a quarter block can be inserted under each shoe. These quarter blocks are worked to the front by successive purchases until half blocks can be inserted in place of the quarter blocks. The half blocks are worked to the front as before until a roller can be inserted under the shoes. When the first roller has been worked nearly under the eccentric axle—near the centre of gravity—embar under the front notches, chock the roller in front, and cant the mortar bed to the rear, catching it on the rollers.

PART V.

ON MOVING AND MOUNTING HEAVY GUNS.

135. *Implements* necessary for moving heavy guns and for mounting and dismounting them, viz.: One hydraulic jack of thirty tons capacity (two would be better, or one jack and a heavy garrison gin); a crab (which is a substantial windlass or capstan mounted on a framework of timber, having a broad heavy base, and with means for *anchoring* it when necessary, the windlass or capstan being worked by a pinion with a bar and cranks operating on a large cog-wheel mounted on the axis of the windlass or capstan); four skids 13 in. by 15 in. and 17 ft. long (yellow pine or oak); eight rollers 6 ft. long by 7 in. diameter, of hard wood, with iron thimbles on each end, and four holes at right angles (1¼ in. diameter) for end of handspike or pinch-bar; six heavy iron pinch-bars, 7 ft. long by 1½ in. diameter; thirty-six blocks, 12 in. by 12 in. and 3 ft. 10 in. long; thirty-six half blocks 6 in. by 12 in. and 3ft. 10 in. long; ten blocks 2 in. by 12 in. and 3 ft. 10 in. long; six blocks 1 in. by 12 in. and 3 ft. 10 in. long; eight blocks 4 in. by 12 in. and 3 ft. 10 in. long; two blocks 8 in. by 12 in. and 5 ft. 2 in. long; two blocks 12 in. by 12 in. and 5 ft. 2 in. long; four blocks 12 in. by 12 in. and 8 ft. long; six shifting planks (oak) 12 ft. long and 3 in. thick; a cradle made of heavy timber with bolsters of such height as to make the breech and muzzle of the gun on about the same level; four iron pulley-blocks, with one, two, three,

and four sheaves (size of blocks for gin); three hundred feet of $6\frac{1}{2}$ in. rope (the fall of gin can be used if long enough); six large wooden handspikes; twelve roller-chocks, and twelve gun-chocks.

The dimensions of blocks here given are the most convenient for the purpose, but smaller and larger blocks may be used, when these are not available.

To move heavy guns.

136. To move a heavy gun a short distance, raise it on skids so that the trunnions will not touch the ground, roll it over by pinch-bars, chocking the breech and *cutting* the muzzle when necessary. A collar on the muzzle of same diameter as breech of gun will be found very convenient. For longer distances, and through narrow passages, mount it on the cradle, with rollers and shifting plank underneath, and if the ground be level it can be moved along with pinch-bars or handspikes; if up a ramp, rig the fall and blocks to the cradle, the crab, and to some fixed or well secured object on top of the ramp, and then work it up with the crab, changing the shifting plank and rollers as required.

TO MOUNT A 15-INCH GUN.

137. The gun is supposed to be in its cradle, the cradle being blocked up to a level with the skidding, one end of which rests on the chassis rails. Each skid is supported near the rail by a crib or scaffold of heavy blocks, piled one on top of the other, two or three in a layer, and brought to a level with the rail. To move the gun from the cradle on to the skidding, the gun must be raised by

hydraulic jacks or the gin, and the skids run underneath. Then with other skids overlapping the first and resting on the chassis rails, the gun by pinching and rolling is brought under its position when mounted on the carriage. The gin or hydraulic jacks are now applied to the muzzle and breech. The cribs or scaffolds to support the muzzle and breech are now placed respectively 3 feet from the muzzle and at the greater swell of the breech. In raising the gun by the gin or jacks, the breech is first raised full 6 inches, a man standing on each side with a chock to prevent rolling. Care must be taken to set the gin or jack vertically over or under the breech, and, when lowering, to ease up gradually, without jerking. The muzzle can now be raised full 12 inches, and blocked and chocked in that position. The skidding is now removed. The breech is now raised an additional 6 inches, always having men on either side ready to chock, and the gun is followed up with blocks so that it cannot fall in case of accident. The blocks used come from the cribs that are no longer required for the support of the skidding. The operation of alternately blocking at breech and muzzle is continued until the gun is above the height of the trunnion-beds, the axis of the trunnions being horizontal. The top carriage is now placed on the chassis and assembled with the trunnion-beds under the trunnions. The gun is then lowered into the trunnion-beds, and the blocks and gin or pumps removed. Another plan, when the top carriage has not been taken apart, is as follows: Place the chassis on the platform and mount the top carriage on the chassis with the gin, and then run the top carriage as far forward as possible. Bring the gun until it is parallel to a convenient position of chassis, and roll the gun over the chassis, having the breech projecting beyond the rear end of the chassis; then raise it by block-

ing under the breech beyond the rails, and under the muzzle by blocking outside the rails with a skidding laid across them, until the muzzle is high enough for the top carriage to be moved back under the trunnions; *the muzzle is raised by the gin and the breech by the hydraulic jack.* Run the top carriage back under the trunnions, and lower the gun into the trunnion beds, removing scaffolding.

In building scaffolding of blocks put the thickest at the bottom, and as we gain in height in raising the gun, replace thin blocks by thicker ones.

Laidley's Gun-lift.

138. The gun-lift recently devised by Col. Laidley of the Ordnance Corps, is a most complete and rapid means for moving and dismounting heavy guns.

In it, the hydraulic jack is placed upon a stand over the gun, whereby the building-up of the crib-work of blocks, which serves as a base for the jack to stand on, is dispensed with and the position of the jack has not to be changed during the operation of raising or lowering a gun. The ordinary carpenter's horse or trestle is taken as the basis of the *hoisting* apparatus. The cap of the trestle, having to sustain the weight of the gun suspended at a distance of more than *two* feet from the points of support, is a large strong and heavy piece of timber, and the legs of the trestle, which are made of 6 in. by 6 in. scantling, have to be strongly braced. The bolster, a strong piece of oak on top of the cap of the trestle, has two mortices cut in it, one for a hoisting bar to *pass through*, and the other for the fulcrum-post to *rest in.* The fulcrum-post has a recess cut on the top to receive the end of a lever and keep it in place. The lever has a mortice through which the hoisting

bar, already mentioned, passes, the latter is perforated with a series of holes through which a pin passes by which the end of the lever, under which the hydraulic jack works, can be fastened to the hoisting bar. The hoisting bar has a hook on its lower end to which the weight to be raised is fastened by means of a sling.

To raise a weight.

139. Pass a sling around the weight bringing the ends over the hook of the hoisting bar, taking in all the slack. Bring the end of the lever down on the head of the jack and put in the pin over it. Commence pumping, and raise the weight the full lift of the jack ; insert a pin in the hole of the hoisting bar, just above the bolster, to support the weight ; take the other pin out and run down the head of the jack, as far as it will go ; bring the lever down as at first, and continue the operation as already described.

To mount a 15-inch gun on its carriage.

140. Two trestles are used, one for the breech and another for the muzzle. The gun is laid on the platform, the muzzle to the front, the vent uppermost, the muzzle about two feet in rear of where the end of the chassis will come, so that when the gun is raised vertically the chassis can be placed on its pintle and directly under the gun. Raise the gun to its full height as already described for raising a weight, run the chassis between the legs of the trestles under the gun and place it on the pintle ; place the top-carriage on the chassis bringing the trunnion-beds under the trunnions and lower the gun into its place.

141. If the gun and carriage be both on the platform, or if the peculiar position of the platform be such as to render the foregoing method impracticable, the following plan may be executed:

Place the gun in such a position that the axis of the bore shall be parallel to the central line of the chassis when the latter is in place. Move the chassis parallel and close to the gun, the top-carriage run well to the front. Put up the trestles over the gun and chassis, both being between the legs of the trestles; hoist the gun, and by means of the jacks raise and slide the chassis under the gun and over the pintle; run back the top-carriage until the trunnion-beds are under the trunnions, and lower the gun into its place.

142. It is possible with the gun-lift for four men to mount a 15-inch gun. A 15-in. gun has been raised from the ground and placed on its carriage in fifty four minutes, and dismounted from its carriage and laid on the ground in forty four minutes. The apparatus can be put up by six men and a director in twenty six minutes.

PART VI.

THE GIN.

143. There are three kinds of gins used in service, the *Field and Siege*, the *Garrison*, and the *Casemate*.

THE FIELD AND SIEGE GIN.

144. When the gin is put together and raised, that part included between the legs and pry-pole is called the inside; the outside being the part without the legs; the right corresponding to the right hand of a man standing at the middle and outside of the windlass, facing towards it; the left corresponding to his left hand.

145. The detachment is composed of the same number of men as prescribed in par. 84. It having been marched to the gin, the instructor teaches the men its nomenclature, and explains the names and uses of the implements.

146. The odd numbers are placed on the right, and the even numbers on the left side of the gin.

147. The gunner, or chief of section, carries the head of the gin (when put together); passes the fall around the pullies at the head of the gin; secures the loose end of the fall to the sling; hooks the single block to it; and superintends the tying of all knots.

No. 1 works the right handspike, and assists in pass-

ing the fall over the pullies, in slinging the piece and moving the carriage.

No. 2 works the left handspike, and assists in passing the fall over the pullies, in slinging the piece, and in moving the carriage.

No. 3 puts the braces in the mortices of the right leg, (works the inside handspike on the right, when there is no pawl and ratchet); keys and unkeys the right cap-squares, and assists in moving the carriage.

No. 4 puts the braces in the mortices of the left leg, (works the inside handspike on the left when there is no pawl and ratchet); keys and unkeys the left cap-square, and assists in moving the carriage.

No. 5 carries the top of the right leg. (places the handspikes of Nos. 1 and 3 in the mortices when there is no pawl and ratchet); and assists in placing the sheaves, and in moving the carriage.

No. 6 carries the top of the left leg; (places the handspikes of Nos. 2 and 4 in the mortices, when there is no pawl and ratchet); and assists in placing the sheaves, and in moving the carriages.

Nos. 7 and 8 work the running end of the fall around the windlass; hold on or ease off; and assist in carrying sheaves and handspikes, in moving the carriages, etc.

Nos. 9 and 10 assist in carrying implements, in moving the carriage, etc.

Mechanical Manœuvres with the Field and Siege Gin.

148. The implements necessary are:

5 *Handspikes* ; (with pawl and ratchet, 2 can be dispensed with, and 2 of the three remaining must be windlass-handspikes.)

1 *Fall.*
1 *Sling.*
1 *Lashing-line.*
1 *Hammer-wrench.*
3 *Shoes,* pieces of plank, with a small hole in each to receive the points of the gin.

To put the gin together.

149. The different parts of the gin having been brought to the place designated, the instructor commands:

PUT THE GIN TOGETHER.

Nos. 1 and 2 bring up the windlass. Nos. 3 and 5 bring the right leg, and lay it with its outside underneath, in its proper position with reference to the windlass. Nos. 4 and 6 bring up the left leg, and place it in a corresponding position. Nos. 7 and 8 bring the sheaves, bolts, and fall, and place them near the head of the gin. Nos. 9 and 10 bring up the braces and pry-pole, and assist Nos. 3 and 4 in putting the braces into the mortices of the left leg, and then into those of the right. Nos. 1 and 2 put in the windlass. Nos. 5 and 6 bring the tops of the legs together and bolt them, when they put in the sheaves and pry-pole. The gunner pins the braces.

To reeve the fall.

150. The gin being put together, and still lying on the ground, the instructor commands:

REEVE THE FALL.

Nos. 5 and 6 raise the pry-pole until it clears the pul-

lies. The gunner, receiving from Nos. 1 and 2 one end of the fall, passes it through the left sheave from below, and hands it back to them. They pass it through the sheave of the single pulley (hooked, for convenience, on the middle brace), and return it to the gunner, who passes it through the right sheave from below, and gives it to No. 1, by whom it is secured by wrapping it around the middle brace.

151. If the gin has been raised, the instructor gives the same command, when the gunner, mounting upon the upper brace, receives from Nos. 1 and 2 one end of the fall, which he passes over the left sheave from without to within.

The fall is then reeved in the manner prescribed.

To carry the gin when put together.

152. The gin is lying upon the ground, its outside downwards.

153. The instructor commands:

CARRY THE GIN.

At this command, the gunner applies himself at the head. Nos. 5 and 6 apply themselves at the ends of the upper braces. Nos. 3 and 4 apply themselves at the ends of the middle braces. Nos. 1 and 2 apply themselves at the ends of the lower braces.

154. The instructor, having indicated the direction, commands:

MARCH.

The men lift the gin together, and march off, keeping step.

155. The handspikes, fall, and sling may be carried either on the gin or by the remaining men.

To raise the Gin.

156. The instructor commands :

1. RAISE THE GIN. 2. HEAVE.

At the 1st command, the gunner applies himself at the head of the gin. Nos. 1, 2, 3 and 4 apply themselves near the upper brace. Nos. 5 and 6 each place a foot against the lower ends of the legs to steady them.

157. At the command, HEAVE, the gin is raised. Nos. 5 and 6 take hold of the pry-pole as soon as there is no longer any danger of the legs slipping, and by pulling down upon it assist in raising the gin.

To move the gin when raised.

158. The instructor, wishing to move the gin a short distance, commands :

MOVE THE GIN.

Nos. 1 and 2 place each a handspike under the windlass from without, retaining the small ends. Nos. 3 and 4

seize the butt ends. Nos. 5 and 6 apply themselves at the handle of the pry-pole.

MARCH.

159. The gin is lifted with care, and placed in the desired position.

To lower the gin.

160. The gin is lowered in a similar manner to that prescribed for raising it. Nos. 5 and 6 raise the pry-pole and assist in easing the gin to the ground, the outside downwards.

To mount a gun.

It is immaterial upon which side of the piece the legs of the gin are placed, but for uniformity they are generally placed on the right.

161. The gin being placed with its pullies directly over the trunnions, and the foot of the pry-pole thirteen feet from the lower brace, the instructor commands:

MOUNT THE PIECE.

No. 1 puts a handspike in the bore. No. 2 passes the eye or loop end of the sling around the knob of the cascable. No. 1 passes the other end under the handspike in the bore and hands it to No. 2, who draws it through the loop and fastens it either by a knot or with the lashing-rope. The gunner hooks the single pulley to the sling just in rear of the trunnions, and fastens the

loose end of the fall to the sling near the same place. Nos. 1 and 2 then go to their places at the windlass. The gunner applies himself to the handspike in the bore to steady the piece. Nos. 7 and 8 pass the running end of the fall from the outside under the windlass, and take three turns with it from right to left around the left of the windlass, they then step back three paces holding on by the running end or slack, No. 7 being nearest the windlass.

Heave.

162. Nos. 1 and 2, or 3 and 4, according to the position of the windlass, place their handspikes in the upper mortices and bear down until the ends of their handspikes are near the ground, the other two handspikes being inserted in the then upper mortices. No. 1 gives the command Heave at which the first two handspikes are withdrawn and tossed to the inside of the gin, the small ends resting on the lower brace and against the legs. Nos. 1, 2, 3, and 4 bear down on the handspikes. Nos. 5 and 6 in the meantime put the disengaged handspikes in the upper mortices. The operation is thus continued until the piece is raised to the required height; No. 1 always giving the command Heave, and Nos. 5 and 6 placing the disengaged handspikes in the upper mortices.

The foregoing directions apply to the old windlass; in case of the one now very generally in use with pawl and ratchet, Nos. 5 and 6 will assist Nos. 1, 2, 3, and 4, at the handspikes if necessary.

Secure the windlass.

163. The men at the handspikes secure the windlass by

allowing the handspike in the upper mortices to bear against the middle brace and legs.

When there is a pawl and ratchet, this is not necessary.

Run up the carriage.

164. All the men except Nos. 7 and 8, bring up the carriage as in par. 103, until the trunnion beds are directly under the trunnions.

Slack off.

165. Nos. 7 and 8 slack off the fall slowly ; the gunner steadies the piece by means of the handspike in the bore; and the piece is lowered into its proper position. Nos. 3 and 4 put on the cap-squares, and key them.

Remark.

166. If, from any circumstance, it is not convenient to sling the piece in the manner prescribed, it may be slung with a short piece of rope passed around each trunnion, and the ends fastened together on the top of the piece ; or, the trunnion-rings may be put on.

Hook the pulley to this sling or to the trunnion-rings ; bear down with one or two men on the handspike in the bore to balance the piece, and when it is raised sufficiently high run the carriage under it, and place a piece of handspike in the trunnion beds and a block on the stock (or on the rear transom in a casemate carriage) to receive the breech. Lower the gun, the trunnions directly over the trunnion beds, until the lower surface of the gun bears on the piece of handspike. Remove the sling from the trun-

nions, and run the carriage, with the gun on it, back until the head of the cheeks are in rear of a perpendicular let fall from the head of the gin. Pass the sling around the chase; hook the pulley to it; and work the gin until the weight no longer bears on the piece of handspike in the trunnion beds; remove this piece, and lower the trunnions to their places; bear down on the muzzle, and remove the block from under the breech.

To dismount a gun.

167. The gin is placed in the same position with reference to the piece as prescribed for mounting it.

168. The intructor commands:

DISMOUNT THE PIECE.

The piece is slung, the cap-squares taken off, and the running end of the fall passed around the windlass, in the same manner and by the same men as prescribed for mounting it.

The commands HEAVE, SECURE THE WINDLASS, RUN OUT THE CARRIAGE, and SLACK OFF, are then given and executed in the manner already prescribed.

Remark.

169. If the ground is not firm, pieces of plank prepared for this purpose, must be placed under the legs and the pry-pole before raising the piece.

To mount a Howitzer.

To dismount a Howitzer.

A howitzer is slung, mounted, and dismounted in the manner already prescribed for the gun.

To sling a mortar mounted on its bed.

170. The sling * is passed under the front notches, then crossed over the top of the mortar and passed under the rear notches. The single pulley is hooked to the sling where it crosses the top of the mortar. The mortar is raised or lowered by the gin in the manner prescribed for the gun.

To sling a mortar without its bed.

171. The sling is passed around the trunnions.

To shift the fall.

172. As the turns gain once the diameter of the fall at each revolution of the windlass, they will, when the weight has been raised a considerable height, come against the opposite leg; the instructor then commands:

HALT—SHIFT THE FALL.

The windlass is secured as in par. 163. Nos. 7 and 8 hold on to the slack. The numbers at the handspikes on the side towards which the turns on the windlass have gained, overhaul a sufficient length of the end of the fall and make a double hitch with it around the leg below the

* Made of 4½ in. white rope, 24 feet long, with the ends spliced together.

lower cross-bar, passing the end inside of the windlass and braces to the chief of detachment, who mounts on the windlass, and makes with it a rolling hitch on the standing part of the fall, near the upper braces, when he descends.

EASE AWAY.

173. No. 7 slacks off until the weight bears on the end of the fall.

SHIFT THE FALL.

174. Nos. 7 and 8 ease the slack. The men at the handspikes shift the turns on the windlass to its opposite end. Nos. 7 and 8 tighten them and hold on.

The men work at the windlass until the weight bears on the fall, when the windlass is secured. The chief of detachment unties the rolling hitch, and the manœuvre is resumed.

Remarks.

175. Six men (including the chief of detachment) are sufficient for mounting or dismounting any siege piece by the siege-gin; but for the purpose of instruction, this gin being more easily handled than the casemate and garrison gins, the same number of men have been prescribed as are necessary for them.

In this case Nos. 1, 2, 3, and 4 work the handspikes; No. 5 holds on to the running end of the fall; and the chief of detachment steadies the piece.

Garrison and Casemate GINS.

176. The garrison and casemate gins differ from the siege gin in having two braces of iron instead of the three wooden crossbars or braces, and in having the pry-pole inserted between the legs, which are kept together by the clevis bolt. The upper pulley (generally treble) is hooked to the clevis.

177. The gin is put together on the ground, and raised by moving up the legs and pry-pole towards each other. The pry-pole has cleats nailed to it to enable a man to mount to the head of the gin to hook on the pulley and to reeve the fall.

178. The gin is lowered by gradually drawing out the legs and pry-pole until the men can get near enough towards the head to support it; it is then lowered upon the piece or on the ground, as the case may be.

Ratchet windlass.

179. A ratchet windlass is now applied to gins, and the handspike is inserted in a box to which a pawl is attached. This pawl catches in the notches of the ratchet when the handspike is borne down, and slides over them as it is raised. Another pawl is hung from the legs which catches in the opposite notches of the ratchet, and prevents the windlass from turning backwards.

As the handspikes are kept in such a position that the men can apply themselves with advantage, one man is enabled with this windlass to raise double the weight he could with one of the old pattern.

NOTE.—In putting in the windlass, care must be taken to make the ratchets and pawl correspond.

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